ABSTRACT BOOK

ISMOM 2024

9th International Symposium of Interactions of Soil Minerals with Organic Components and Microorganisms

Commission 2.5 Soil Interfacial Reactions
International Union of Soil Science

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9th International Symposium on
Interactions of Soil Minerals with Organic Components and Microorganisms

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Management practices and soil organic C: lessons learned, controversies, and knowledge gaps

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Much has been written and said about the opportunity and feasibility of sequestering atmospheric C in agricultural soils to mitigate climate change. Criticisms have come in part from the uncertain global potential that soil C sequestration may represent, and this despite the decades of research on the impact of agricultural management practices on soil organic C (SOC). Some of this uncertainty originates from the large variability in soil, climate and cropping practices which induces variations in response to management. Another source of difficulty is the small and slow response of SOC to changes in practices relative to the large and variable SOC stocks. Differences in measurement and accounting methods have also contributed to cause confusion and uncertainties. In this overview, I will illustrate some of these challenges and controversies for a few selected management practices.

The still debated question of the impact of reduced- or no-tillage (NT) on SOC is a good example. For decades, the impact of tillage on SOC was only measured in the surface few cm of soil which has led to the general consensus that NT had a positive effect on SOC. However, research has shown that accounting for deeper soil layers can lead to different conclusions, sometimes decreasing (or annulling) the positive effect of NT, or sometimes even increasing it. There is now mounting evidence that the positive impact of NT on SOC is dependent on climate, with positive effects under drier, tropical or Mediterranean climates, most often concomitant with improved crop yield and C input. The fact that in many situations there is little to no effect of long-term tillage on whole-soil SOC stocks questions the hypothesis that reduced- or no-tillage favors physical protection of organic C, or that conversely, tillage reduces physical protection of SOC.

The impact of cover crops on SOC has also been the subject of much debate. Although there is no plausible hypothesis why cover crops should not significantly enhance SOC, there has been a number of studies not showing any impact. Better understanding and assessing the impact of cover crops is essential as it is often the only lever available in arable cropping systems. The regular addition of significant amounts of high-quality biomass (including roots and rhizodeposition) must be beneficial for SOC storage but the actual potential of high-quality residues on SOC and their incorporation in more stable fractions such as MAOM (mineral-associated organic matter) remains a debated question.

Grasslands generally present large SOC stocks and their preservation is essential. However, the possible further enhancement of already C-rich soils through livestock and grassland management is subject to much uncertainty, especially in light of the current highly-debated question of whether soils have an actual maximum capacity (or saturation) to store and stabilize organic C.

Although uncertainty does exist and actual mechanisms of (de)stabilization are not always fully understood, SOC sequestration in agricultural land is possible in most situations; but agronomic solutions have to be fine-tuned to local soil/climatic conditions. However, it should not be considered a ‘silver bullet’, which will alone solve the current climate crisis. The absolute priority should be to reduce greenhouse gas emissions from all sectors, including agriculture, and that includes preventing further losses from already C-rich soils.

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Soil and Climate Change: Evolving Policy Landscapes and Intersections

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Recent developments in U.S. and global environmental policy increasingly recognize the intricate connections between climate change, soil health, and food security. Policymakers now view climate change as a "threat multiplier," acknowledging its role in exacerbating land degradation and food insecurity worldwide. In response, there's growing emphasis on climate-smart soil management practices that aim to improve soil health while mitigating climate change impacts and enhancing agricultural resilience. This talk focuses on recent U.S. policy developments incorporating soil health considerations in climate and other related strategies. I will discuss a select few key legislative initiatives and agency-level programs highlighting soil health's increasing prominence.

From organo-mineral interactions to soil and carbon policies

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In the last years, soils and soil carbon are increasingly being considered in policies at different levels. At the international level several countries include C sequestration in soils in their nationally determined contributions in the framework of the Paris Agreement. At the European scale, the European Commission is proposing a Soil Monitoring and Resilience Directive and a Carbon Removals Certification Framework. These policies need a wealth of knowledge, such as C-related indicators, estimates of C sequestration potentials and measuring reporting and verification systems. The demand is also for clear and stabilized terminology, authoritative information, context-stratified information and harmonized methodologies. Examples at this challenging science – policy interface will be given, demonstrating that studying organo-mineral interactions may contribute to soil and carbon policies.

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Microbe-Mineral-Organic Matter Interactions at Pore to Hillslope Scales

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The evolution of soil structure over millennia results from event-based interactions among minerals, fluids and biota operating at the microscale within pores and at interfaces. However, pore-scale biogeochemical gradients and compositions depend on the landscape-scale context, including fluid flow paths, root distributions, water residence times, and prevalence/distribution of diverse pools of organic matter. To explore variation in mineral-organic-microbe interactions, we are measuring spatiotemporal correlations among several biogeochemical and microbial parameters across two-dimensional hillslope cross-sections at several critical zone observatory (CZO) sites across the U.S. Ridge, backslope and toeslope positions were excavated to depth of refusal with soil sampling conducted at 5-10 cm increments, root distributions quantified, and CO_2, O_2, moisture and temperature sensors installed at 3-4 depths prior to backfilling. Samples were analysed for quantitative mineralogy and geochemistry, extractable metals and nutrients, solid phase and dissolved organic matter, enzyme activities, and microbial community composition. Selected samples were subject to molecular speciation of iron and manganese using synchrotron-based X-ray absorption spectroscopy.

Results indicate that sites differ in the time dependent response of soil gases to rainfall events, with time series of wetting front propagation reflecting the connectivity of subsurface fluid flows. Periodic anoxia occurs at depth during periods of concurrent saturation and elevated soluble organic matter, with effects on bioavailable ferric (oxyhydr)oxides. Microbial community composition and enzyme activities exhibit corresponding trends with depth that signal differences between connected and unconnected subsurface flow paths. Integrated data analyses highlight linkages among weathering-induced transformations of soil minerals, organic matter transport, root distributions and microbiome composition and activity. We examine how these linkages vary across climates, biomes, and landscape positions to promote a more comprehensive, predictive understanding of the complex interactions that govern critical zone evolution and response to rapidly-changing environmental conditions.

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Nature, time and humans: Why we need a landscape perspective to get soil organic matter cycling right at larger scales

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Soil data gaps for numerous regions and a lack of understanding of biogeochemical processes across diverse soil landscapes are the main barriers to larger-scale representation of soil organic matter dynamics. These are critical challenges for predicting trajectories or management options for the terrestrial carbon cycle. In my talk I will illustrate how a greater consideration of soil formation theory can deliver valuable insights about future soil organic matter sequestration, turnover, and stabilization but necessitate a landscape-centric perspective. Giving examples of major soil alterations in the past, present, and future, I highlight the peril of oversimplified generalizations when scaling drivers of SOM dynamics from local to global and vice-versa. These examples reveal the need to account for long-term alterations of the soil matrix. Such an approach may prove particularly valuable in enhancing forecasts for the soil C cycle in polar and tropical regions experiencing rapid environmental changes and featuring soil properties distinct from those presupposed in current Earth System Models.

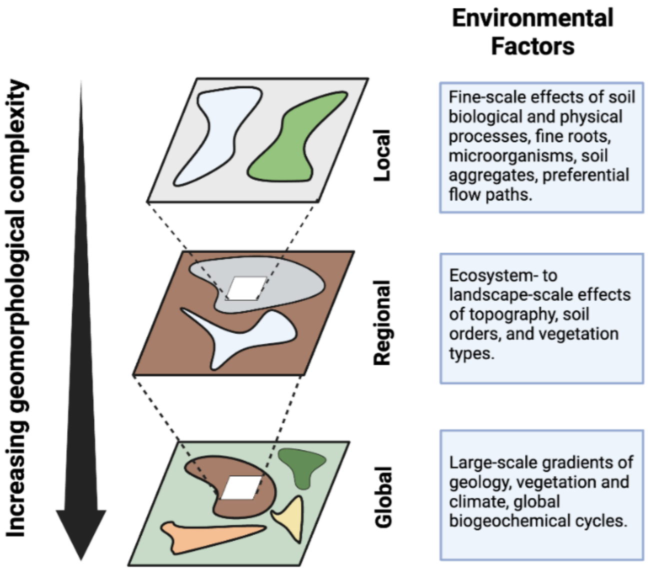

Figure 1. Conceptual model linking controls relevant for SOM dynamics across spatial scales. The influence of increasing geomorphological complexity that structure soil landscapes is shown in relation to environmental factors relevant to SOM dynamics. As larger spatial scales are considered, the overall geomorphological complexity increases, and the environmental factors that best explain this variability shift.

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Spatial heterogeneity in soils – Assessing microbial metabolism

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Soils are structurally heterogeneous across a wide range of spatio-temporal scales. Consequently, external environmental conditions do not have a uniform effect throughout the soil, resulting in a large diversity of micro-habitats. Soil biologists are therefore confronted with the issue of how to deal both conceptually and experimentally with such a high degree of diversity and array of interactions. However, microbial metabolism is often evaluated in sieved samples, which provides information on gross potentials under optimised conditions. Such gross measurements rarely reflect reality and, based on theoretical considerations, it is expected that higher heterogeneity in soils would decrease microbial activity.

In this talk, I will explore experimental and theoretical considerations when assessing microbial metabolism taking into account spatial heterogeneity in soils. The first part of the talk will focus on testing the scale transition theory (Chakrawal et al., 2020. Geoscientific Model Development 13, 1399) experimentally, and the second part will centre around the use of soil structural indicators as predictors of microbial metabolism under various agricultural soil tillage systems. Finally, I would like to (i) address practical considerations when measuring microbial metabolism in undisturbed soil samples and (ii) tackle the question “Why, when and how does the spatial heterogeneity of soils matter when assessing microbial metabolism?”

Behavior of organic carbon governed by soil components interplay

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As the largest reservoir of organic C in terrestrial ecosystems, soil plays critical roles in decelerating the emission of greenhouse gases to the atmosphere and abating global climate change. Soil is a multi-phases system encompassing various biotic and abiotic components which form a range of structures or aggregates with different sizes. Disentangling the accumulation mechanisms of organic C at the soil interface is fundamentally important for the understanding of the long-term preservation of OC in soils. Modern spectroscopic, microscopic, calorimetric and molecular biology techniques offer powerful tools for the studies of these purposes. By integrating AFM, FE-EPMA, NanoSIMS, Nano-CT, FTIR and NEXAFS techniques, we show how soil mineral-microorganisms interactions affect the retention of OC at microscale interface and aggregate level.

1) We reveal that the adhesion of bacterial biomass and microbial derived necromass to soil minerals is largely dependent on the type and size of mineral particles and bacterial species. Iron oxides are the strongest, among various soil minerals, in inhibiting bacterial activity via van der Waals and electrostatic forces and P-O-Fe bonds. The adsorption affinity of microbial EPS on Fe oxides follows the sequence of P-, N- and C-containing moieties. Phosphate groups of EPS form monodentate and bidentate innersphere complexes at acidic and alkaline pHs, respectively. The EPS-N is relatively enriched during adsorption, while more EPS-C and EPS-P are fixed in the coprecipitation process.

2) We propound that organo-organic interactions drive the accrual of SOC, challenging the prevailing “C saturation” concept. Despite the unsaturation of soil mineral surfaces in two typical soils, the newly incorporated C is found to be predominantly adhered to "dirty" mineral surfaces coated with OC, demonstrating the crucial role of organo-organic interactions in exogenous C sequestration which is not constrained by mineral vacancies. The coverage of native OM by new C, representing the degree of organo-organic interactions, is noticeably larger in Ultisol (~14.2%) than in Mollisol (~5.8%). Organo-organic interactions are primarily mediated by polysaccharide-rich microbial necromass on iron oxides.

3) We show a trade-off between the physical and chemical protection of OC varying with aggregate size. Pore structure and minerals contribute equally (50%) to OC accumulation in soil macroaggregates, while chemical protection plays a leading role in C retention (53.4% – 59.2%) in microaggregates. We also reveal the protists-driven trophic interactions in soil C cycling at aggregational level. Bacterivores are the predominant protistan group and are more abundant in macroaggregates and silt + clay than in microaggregates, while omnivores exhibit an opposite distribution pattern. Omnivores and bacterivores impact positively and negatively on the C-decomposition genes and SOC contents, respectively. Microbial trophic interactions are intensive in macroaggregates and silt + clay, but are restricted in microaggregates, as indicated by the intensity of protistan-bacterial associations and network complexity and connectivity.

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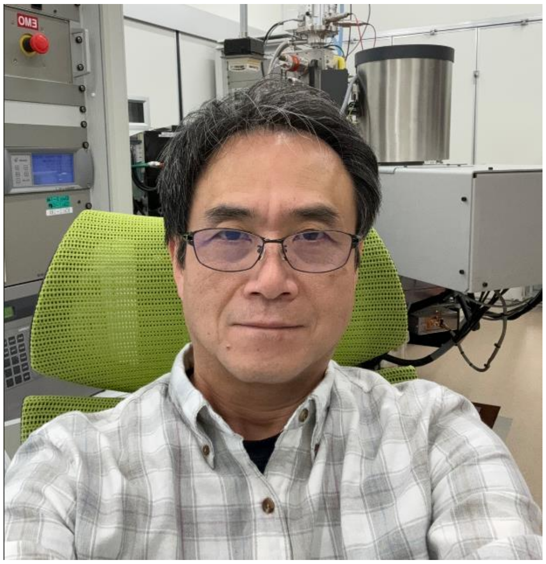

Fantastic voyage to the Asteroid Ryugu: a world of clays and organics

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The Hayabusa2 spacecraft brought surface and/or subsurface materials to Earth from the carbonaceous-type (C-type) asteroid Ryugu in December 2020. They may have transported volatiles to the inner Solar System and created the conditions suitable for life on Earth. Carbonaceous chondritic meteorites are fragments of C-type asteroids and provide evidence that these generally organic-rich bodies experienced extensive aqueous alteration in the earliest history of the Solar System. So far, substantial reports on the Ryugu materials have been published (e.g., Ito et al. 2022; E. Nakamura et al. 2022; Yokoyama et al. 2022; T. Nakamura et al. 2022; Noguchi et al. 2022; Okazaki et al. 2022; Naraoka et al. 2023; Yabuta et al. 2023). These analytical results cover mineralogy, petrology, abundances of elements and isotopes, and organic components such as molecular structures and their diversity.

Here Phase2-curation Kochi team present the results of an integrated bulk and micro-analytical study of Ryugu particles. Petrological, mineralogical, bulk elemental, and oxygen isotopic characteristics (Ito et al. 2022; E. Nakamura et al. 2022; Yokoyama et al. 2022) indicate that the Ryugu particles are very similar to CI chondrites (e.g., King et al., 2020) indicating representative elemental abundances of the Solar System. Ryugu particles consist of fine- and coarse-grained phyllosilicates (64–88vol%, serpentine–saponite intergrowth). Coarse-grained phyllosilicates as feathery aggregates (up to several tens of micrometres in size) occur in the fine-grained phyllosilicate-rich matrix (smaller than a few micrometres in size). Carbonates, sulfides and magnetites occur in the phyllosilicate matrix. The exception is the absence of ferrihydrite and sulfate in the Ryugu particles, which indicates that these minerals in CI chondrites formed due to terrestrial weathering (e.g., T. Nakamura et al. 2022; Yamaguchi et al. 2023).

We conducted a coordinated micro-analysis utilizing STXM-XANES (carbon functional groups), NanoSIMS and TEM. We found a unique insight into the relationship between aliphatic-rich organics and the surrounding phyllosilicates at sub-micrometer scale during water-rock interactions. The aliphatic-rich organics may be widely distributed in C-type asteroids and exist in close association with phyllosilicates. This is consistent with the previous report of aliphatic/aromatic CH in the Ryugu particles demonstrated by the on-board MicrOmega of the

Hayabusa2 spacecraft (Pilorget et al., 2021). Note that organics in Ryugu particles exhibited aromatic-rich by another research group (e.g., Yabuta et al. 2023; Changela et al. 2024) indicating a diversity of carbon functional groups. An important and as yet unresolved question is whether the unique nature of the aliphatic carbon-rich organics associated with phyllosilicates observed in this study is found only in the Ryugu asteroid. H and N in the FIB sections generally show heavy isotopic compositions. Isotopic variations show similarities with those seen in interplanetary dust particles and cometary returned samples but are higher than CM and CI chondrites, indicating that they are derived from the outer Solar System region (e.g., Alexander, 2017).

Our findings clearly shows that Ryugu particles are undoubtedly among the most uncontaminated Solar System materials available for laboratory study and ongoing investigations of these samples are expanding our understanding of early Solar System processes.

References

Alexander, C. M.O.'D. (2017) *Phil. Trans. R. Soc. A* 375, 20150384; Changela et al. (2024) *Nat Commun* 15, 6165; Ito, M. et al. (2022) *Nat. Astron.* 6, 1163–1171; King, A. J. et al. (2020) *Geochim. Cosmochim. Acta* 268, 73–89; Nakamura, E. et al. (2022) *Proc. Jpn Acad. Ser. B* 98, 227–282; Nakamura, T. et al. (2022) *Science* 379, eabn8671; Naraoka et al. (2023) *Science* 379, eabn9033; Noguchi et al. (2023) *Nat Astron* 7, 170–181; Okazaki et al. (2022) *Science* 379 eabo0431; Pilorget, C. et al. (2022) *Nat. Astron.* 6, 221–225; Yabuta et al. (2023) *Science* 379, eabn9057; Yamaguchi, A. et al. (2023) *Nat Astron* 7, 398–405; Yokoyama, T. et al. (2022) *Science* 379, eabn7850

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The fine-scale spatial organisation of the soil microbiome scales

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Soils contain the Earth's highest microbial diversity, likely due to their spatial complexity and heterogeneity at microbially relevant scales. Soil is composed of micro- to millimeter-scale aggregates of organic matter, minerals, and microbes, which form, stabilize, and disintegrate in a dynamic and recurrent way, closely tied to microbial activity. As such, aggregates provide a temporally and spatially limited interaction space for microbial communities and their environment. However, the impact of this dynamic structure on soil microbial ecology and organic matter turnover remains unknown.

To explore the link between microbial communities and organic matter turnover at the aggregate scale, we analyzed bacterial and fungal communities and physico-chemical properties in over 200 hand-picked 2-mm forest soil aggregates and compared them to bulk soil samples.

Microbial communities in even nearby individual soil aggregates were highly distinct, showing exceptionally high beta-diversity. Up to 30% of microbial taxa, particularly rare ones, were unique to individual aggregates selected within a few cms, emphasizing small-scale spatial heterogeneity. The δ13C values, a proxy for the degree of recycling of soil organic carbon, were consistently higher in aggregates than in bulk soil, indicating that aggregates were enriched in carbon already processed by microbes. Microbial composition and richness were closely linked to organic matter properties, suggesting that aggregates provide stable environments long enough for the co-development of microbes and their surroundings. Co-occurrence patterns between certain fungal and bacterial groups suggest that environmental selection and trophic interactions drive local community assembly.

In summary, our findings show that mm-sized soil aggregates harbor unique microbial communities, with their diversity and composition tightly linked to organic matter quality and carbon recycling. This suggests that the soil microbiome should be viewed as a metacommunity, where subcommunities exist at various successional stages shaped by organic matter properties and abiotic conditions within aggregates. Key soil functions, such as carbon cycling and stabilization, emerge from interactions within aggregates and between aggregate dynamics and microbial activity, with the ecology of microbial communities being profoundly influenced by a constantly changing microhabitat landscape.

Pan Ming Huang Prize Award Talk

Resolving the Molecular Complexity and Dynamic Nature of Mineral-Organic Interactions in Soils

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Interactions among (micro)biota, minerals, and organic matter play a crucial role in regulating soil carbon pools and their response to environmental change. In this talk, I will explore the molecular complexity and dynamic nature of mineral-organic interactions. These interactions are complex because, while they can protect organic matter from microbial access, they are inherently reversible due to the influence of plants and microbes—and in some cases, mineral-organic interfaces may even accelerate organic matter decomposition! The challenge of studying these interactions is further compounded by their dynamic nature, as the reactivity and impact of mineral-organic interfaces shifts in response to soil processes occurring over daily, seasonal, and pedogenic time scales. I will discuss both recent breakthroughs and ongoing challenges in understanding these intricate interactions and their response to change.

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How does fire affect the nature and stability of soil organic C and N? implications for biochar management

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Worldwide, vegetation fires represent disturbances with considerable environmental impact. With respect to soils, they lead to charcoal inputs commonly assumed to contribute to an efficient sequestration of C from the global C cycle. Although considerable contributions of PyOM were evidenced in Black soils around the world, results of other studies are questioning the longevity of charcoal residues by reporting mean residence times comparable to those determined for naturally humified soil organic matter (SOM). Studies on natural fire-prone Mediterranean ecosystems confirmed a quick decrease of PyOM contributions to SOM already during the first post-fire years, either by erosion processes, masking by the input of new and fresh litter and by biochemical degradations. Most likely, charged functional groups within the aromatic network of PyOM,, increase the biochemical accessible to a higher extent than formerly assumed. Analyzing PyOM in soils of various fire-prone regions evidenced selective preservation of such carboxylated PyOM, in particular in deeper soil horizons. Here, their biochemical recalcitrance is enhanced - possibly by oxygen depletion - whereas the degradation rate of non-pyrogenic SOM remains unaffected. It is evident that the longevity of PyOM in soils depends largely upon its chemistry and the environment in which it is accumulating. Indeed, this does not only apply for PyOM formed by vegetation fires but seems to be also valid for so-called biochar (BC) produced by controlled pyrolysis of organic residues. Used as soil amendment, BC is expected to enhance plant growth by supplying and, more importantly, retaining nutrients and by providing other services such as improving soil physical and biological properties. In addition, the application of BC to soil or as a peat replacement in gardening soil has been proposed as a novel strategy to mitigate the emissions of carbon dioxide to the atmosphere. However, comparable to fire-derived PyOM; BC can greatly vary in its chemical compositions and physical properties which will determine its performance in soils and garden substrates. Thus, it is important to bear in mind that BC application is not a “one-size fit-all paradigm” but instead requires careful consideration of the properties associated with each particular biochar and how those properties might remedy a specific soil/substrate deficiency or alter soil organic matter (SOM) characteristics. Therefore, in my presentation, the relationship between the chemical and physical properties of PyOM and BC and C and N cycling in soils and gardening substrates will be discussed based on former and recent experiments.

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Microbial geography within the constrains of soil structure – are we there yet?

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Soil organic matter (SOM is a key binding substance shaping soil structure, while being protected by the structure it creates. Creation, storage, and protection SOM is enabled by a complex community of microorganisms; and SOM is both an outcome of their functioning and their driver and energy source. SOM protection stems from the tightly interwoven key physical/biological drivers, including properties of soil mineral surfaces, quantities and spatial patterns of new C additions, and their accessibility to microbial communities capable of its processing. Understanding the contribution of spatial micro-environmental variations in microbial functioning is crucial for development of mechanistic process-based models predicting future SOM changes. Microbial activity takes place within a highly complex physical frame of soil pore structure; it is strongly affected by constantly changing water distribution patterns within the pores; and heavily relies on extremely spatially and temporally variable C inputs from SOM, plant roots, and organic residues.

There is mounting evidence that composition of soil microbial community does matter for a variety of processes involved in plant-soil-microbial interactions with sizeable implications for plant growth, thus, potentially, for SOM gains and protection. Hence comes the growing importance to understand soil microbial habitats, their physical characteristics, the organisms populating them, and the functions such organisms can perform. We will present examples of recent efforts in exploring soil microenvironments, both from literature and from experiments conducted in our lab, with the focus on identity and functions of bacterial inhabitants. A couple of examples will represent experiments with soil aggregates of different size groups, where micro- vs. macro-aggregates are used as proxies for underlying microhabitats, while the others will report findings from exploring soil bacterial communities within pores of different sizes using the matric exclusion principle combined with stable isotope probing.

We will then discuss a proposed classification of soil microhabitats based first, on availability of C resources, and, second, on availability of water and O_2. The first classification level separates the soil matrix into C-rich domains of rhizosphere, detritusphere, drillosphere, etc., vs. C-poor bulk soil. The second level is defined by the origin, abundances and characteristics of soil pores, the avenues of water and gas fluxes. We argue that developments in X-ray computed tomography scanning enable accurate and relatively efficient identification and quantification of C-resource-based and pore-based microhabitats in intact soil samples. Combining such quantitative descriptions with knowledge of microbial community compositions and of their prevailing functions within specific microhabitats offers new opportunities for modeling soil processes, especially those driving SOM gains and protection.

Microscale self-organization of mineral-associated organic carbon for macroscale global predictions

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Since the 1940s, research on soil organic matter (SOM) has focused primarily on aggregate formation rather than the interaction between SOM and mineral components. This is because of the difficulties in isolating naturally occurring primary organomineral complexes. It was not until 1967 that mineral complexes and aggregates were considered one model by Edwards and Bremner [J. Soil Sci. 18 (1967)]. They proposed that polyvalent cation binding to SOM was the main process leading to microaggregate formation. Later, Tisdall and Oades [J. Plant Soil Sci. 62 (1982)] introduced the idea of aggregate hierarchy with spatial and temporal dependency, and Oades [Plant Soil 76 (1984)] discussed the formation of microaggregates within macroaggregates. The separation of soil into primary organomineral complexes of different sizes is based on the SOM associated with mineral particles of various sizes at a microscale (e.g., < 20 µm). This process differs from the formation of macroaggregates, a secondary soil structure at a larger scale (>250 µm). In this talk, I revisited the primary organomineral principle, beginning by acknowledging the misinterpretation of the element enrichment factor, coined by Christensen [Acta Agric. Scand. 35 (1985)] and utilized as an early saturation concept to the present day where a similar notion is used to estimate the SOC saturation deficit. However, a simple mathematical arrangement reveals that this concept has always been, indeed, the mineral-associated organic carbon (MAOC) of Hassink [Plant Soil 191 (1997)] used to establish the carbon preservation capacity of soils. We demonstrate that the MAOC of nonvolcanic soils is far from saturation, but the MAOC of volcanic soils is closer to saturation. We also show how andic properties are dramatically reduced due to intensive agricultural management, resulting from a tradeoff between stable carbon pools and particulate organic matter. Understanding these mechanisms at different scales is critical for monitoring and modelling SOM processes to forecast soil carbon sequestration with reduced uncertainty.

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From economics of land to economics of soils: implications for public policies and private markets

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Public policies have traditionally considered soils as part of broader land management frameworks. Similarly, economics has historically focused on land use, land ownership, and associated agricultural productivity, rather than specifically on soils. However, soils fulfil a wider range of roles and functions that help provide vital ecosystem services, including carbon sequestration, but also in terms of regulating water, filtering and buffering potential pollutants, biodiversity support, and many others. Soil economics aims to delve deeper into the specific functions and services provided by soils, tracing economic and social impacts of soil ecosystem services. The focus on soils in economic terms is essential for developing more nuanced public policies and creating robust private markets, particularly in the context of emerging carbon credit systems and sustainability agendas. Not all ecosystem services provided by soils, however, can easily be measured in monetary terms. Therefore, multi-criteria decision-making frameworks and cost-effectiveness approaches can better contribute to designing public policies tailored to preserve and enhance soil health. This paper explores the evolution from land economics to a more focused understanding of soil economics, analysing how this shift can better inform public policies and stimulate private market mechanisms such as carbon credits. The concept of carbon sequestration in soils is central to the emerging markets for carbon credits, where businesses and industries seek to offset their emissions by investing in activities that remove carbon from the atmosphere. Soils are one of the most significant carbon sinks on Earth and increasing soil carbon content offers a win-win solution for climate action and agricultural productivity. However, for carbon credits related to soil carbon sequestration to be effective, there must be robust and standardized methods for measuring, reporting, and verifying soil carbon changes. Private markets can play a critical role for facilitating investment into soil health. By recognizing soils' multifaceted value and their critical role in climate change mitigation, policymakers can more effectively incentivize sustainable soil management practices.

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Oral session

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What are the organo-mineral associations called 'nanoCLICs'?

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Organo-mineral associations in the form of coprecipitates are increasingly cited in the literature as a key mechanism of interaction between organic matter and soil minerals. Coprecipitates thus emerge as essential soil bodies in controlling carbon dynamics in soils. Their transitional structural/nature as well as their precise formation and maturation/transformation mechanisms remain poorly understood.

Over the past 10 years, we have aimed to: (1) model the molecular structure of these coprecipitates (Basile-Doelsch, *et al.*, 2015; Tamrat, *et al.*, 2018; Tamrat, *et al.*, 2019) (2) observe and characterize them down to the nanoscale (Jamoteau, *et al.*, 2023; Jamoteau, *et al.*, in prep), (3) test their stability against mineralization by microorganisms (Jamoteau, 2023), and (4) explain their formation mechanisms in soils in relation to microbial activity (Girard, *et al.*, in prep). Our work relied on both synthetic samples (laboratory coprecipitates) and natural andosols, and we employed complementary approaches combining physicochemistry, microfluidic systems, respirometry, electron microscopy (SEM, TEM), and spectroscopy (EXAFS, STXM, EDX, EELS) to characterize the nature, the structure and the dynamics of coprecipitates.

This contribution will provide a synthesis of the studies conducted on these organo-mineral structures called "nanoCLICs" for nanosized coprecipitates of inorganic oligomers with organics. We demonstrate that nanoCLICs could represent, within soil constituents, an ultimate boundary between biotic and abiotic components. NanoCLICs could thus play major roles in the biogeochemical dynamics that control soil functioning.

Basile-Doelsch, I. *et al.* Are Interactions between Organic Compounds and Nanoscale Weathering Minerals the Key Drivers of Carbon Storage in Soils? *Environ. Sci. Technol.* **49**, 3997-3998, doi:https://doi.org/10.1021/acs.est.5b00650 (2015).

Girard, T. *et al.* Successive biogenic and abiogenic processes lead to the formation of organomineral associations as coprecipitates. (in prep).

Jamoteau, F. *Stocker du C dans les sols : dynamique des matières organiques en interaction avec les nanophases du sol*, Aix-Marseille University, (2023).

Jamoteau, F. *et al.* Structure and Chemical Composition of Soil C-Rich Al–Si–Fe Coprecipitates at Nanometer Scale. *Environ. Sci. Technol.* **57**, 20615-20626, doi:10.1021/acs.est.3c06557 (2023).

Jamoteau, F. *et al.* Does agricultural land use impact the nanostructure of organomineral associations in andosols? (in prep).

Tamrat, W. Z. *et al.* Composition and molecular scale structure of nanophases formed by precipitation of biotite weathering products. *Geochimica et Cosmochimica Acta* **229**, 53-64, doi:https://doi.org/10.1016/j.gca.2018.03.012 (2018).

Tamrat, W. Z. *et al.* Soil organo-mineral associations formed by co-precipitation of Fe, Si and Al in presence of organic ligands. *Geochimica et Cosmochimica Acta* **260**, 15-28, doi:https://doi.org/10.1016/j.gca.2019.05.043 (2019).

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Influence of plant litter quality on soil carbon accumulation patterns in the converted upland from lowland paddy in Japan using ^{13}C-labeled residues

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Abstract

In recent years, converting lowland paddy fields to upland fields has become an essential agricultural policy in Japan. Land use change, from paddy to upland, should affect the soil C dynamics, due to changes in the environmental conditions and the crop residue quality (e.g., C:N ratio/plant species). Plant residue quality mainly affects its mineralization and accumulation patterns. Past studies reported that high quality litters (low C:N) increased mineral-associated organic C (MAOC), while low quality litters (high C:N) contributed more to particulate organic C (POC). However, the effect of land use conversion, i.e., converted upland from lowland paddy on soil C dynamics related to the plant litter quality is still unclear. Our study aimed to evaluate the *in-situ* litter-derived C accumulation patterns in converted upland soils using different plant litter quality. We conducted the *in-situ* incubation experiment with six different ^{13}C-labeled plant residues of soybean and maize (C:N ratios 15−54; added 2 Mg C ha^{-1}, equivalently 1.28 g C kg^{-1} soil) at the experimental field of Tokyo University of Agriculture and Technology. We measured the C content and the abundance of ^{13}C in bulk soil and fractionated soil, such as light fraction (LF), POC (53−2000 μm), and MAOC (<53 μm), at 30, 90, and 180 days after installation (DAI). Results showed that 24.7−49.8%, 19.3−38.8%, and 17.5−34.2% remained at 30, 90, and 180DAI in bulk soil, and there was a clear difference for the crop species and also for the residue qualities. Litter-derived C in bulk soil from maize leaf (0.44 g kg^{-1} soil), stem (0.38), and root (0.40) were larger than that from soybean leaf (0.33), stem (0.22), and root (0.34) at 180DAI, respectively. It indicates soybean residue's lower C accumulation characteristics, while soybean residue has a lower C:N ratio than maize. Litter-derived C of whole residue types were firstly in LF compared to POC and MAOC at 30DAI, while these were in POC and MAOC at 90 and 180DAI, indicating the C transformation from labile fraction to more stable fractions. Finally, most litter-derived C was in MAOC (53−78%) rather than in LF and POC at 180DAI. We also found a larger litter-derived C in MAOC from the leaf than the stem of both soybean and maize, indicating the high-quality litter characteristics should contribute to larger C accumulation in each crop species. At the conference, we will also present and discuss the effect of residue chemical properties (e.g., lignin and hemicellulose contents) on C accumulation patterns.

Keywords: *C sequestration, isotopic tracing, plant litter quality, lowland soil.*

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Promotion of carbon storage by weathering of pristine phyllosilicate at the decadal timescale

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Weathering can significantly alter the mineral matrix from pristine minerals on an annual timescale in horizons subjected to intense biological activity but little is known about how this initial weathering contributes to carbon storage as mineral-associated organic matter.

To address this knowledge gap, a mesh bag incubation was conducted in acidic soil of a Douglas-fir forest in the Beaujolais area (France). Large Na-saturated and organic carbon-free vermiculite particles (200–400 mm in size) were placed just below the forest floor and at a depth of five centimeters. The vermiculite bags were retrieved after four, six and twenty years. Over the course of 20 years, the vermiculite particles have undergone significant weathering, especially below the forest floor. Dissolution has progressively released up to 10% of the structural elements, while the cation exchange capacity has decreased significantly due to interlayer Al hydroxylation. Secondary minerals, including Mn oxides, have deposited on the vermiculite outer and inner sheet surfaces. Concurrent with the weathering process, the carbon content of the vermiculite particles has increased up to 5 mg.g-1.

Transmission electron microscopy performed on focus ion beam sections revealed the formation of nano- to micro-sized exfoliation spaces inside the vermiculite particles, increasing with the incubation time. Organic matter colocalized with calcium was entrapped in these exfoliation spaces, sometimes in association with Mn oxides, amorphous Si or other secondary mineral deposits.

These results provide new evidence that structural changes induced by weathering at the submicrometric scale in large pristine vermiculite particles are responsible for trapping organic matter over a decadal timescale. Further investigation is required to generalise this finding and to determine the stage at which weathering progresses to the point of complete separation of vermiculite sheets and exposure of organic matter to decomposers.

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Mineral-organic associations influence the capacity and vulnerability of soil carbon storage

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Chemical and physical associations of carbon with minerals play a critical role in soil carbon storage and persistence. At the global-scale, mineral-associated carbon constitutes the largest component of soil organic carbon in non-permafrost mineral soils. However, the capacity and vulnerability of mineral-associated carbon remains uncertain. Leveraging measurements of soil carbon fractions from > 1,100 globally-distributed soil profiles, we present the first spatially-resolved global estimates of mineral-associated carbon stocks and carbon-storage capacity. Critically, we find that the proportion of carbon stabilized through associations with soil minerals can play a dominant role on the emergent climatological temperature sensitivity of bulk soil carbon stocks. Indeed, we find that the temperature sensitivity of particulate carbon can be nearly 30% higher than that of mineral-associated carbon, and up to 55% higher in cooler climates. To improve projections of carbon cycle-climate feedbacks and inform soil management, it is imperative to assess underlying soil carbon fractions to accurately predict the distribution and vulnerability of soil carbon.

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Chemical properties of soil organic matter resposible for abailable nitrogen

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The productivity of soil ecosystem largely depends on the availabilities of inorganic nitrogen (N) (NH_4^+ and NO_3^-) generated in the soils, but the chemical background of the source of inorganic N has not been clarified. In Japan, organic N extracted with hot water at 80°C for 16h has been regarded as available N which will be mineralized into inorganic N during a cultivation period in upland fields, because the amounts of N in this fraction have a good correlation with those mineralized during four weeks of incubation irrespective of soil types and the history of organic amendment applications. In this study, the authors investigated the chemical properties of this fraction from a volcanic ash soil (Andosol), a fluvial paddy soil (Anthrosol), a granitic sandy forest soil (Arenosol), and a red-yellow soil (Luvisol), by using solid state ^{13}C cross polarization magic angle spinning (CPMAS) nuclear magnetic resonance (NMR) spectroscopy (ECA400, JEOL) and isotopic ratio mass spectrometry (MAT253 coupled with Flash2000, Thermo Fisher Scientific). The available N fractions from four different soils showed very similar ^{13}C NMR spectra having four main peaks at around 175, 101, 72, and 22 ppm, with small accessary peaks at around 130, 63, and 40 ppm. Deconvolution of the NMR spectra gave well resolved quantitative peak areas, and 3.2 to 7.0% of C were assigned to anomeric C1 position (anomeric C) of sugar moieties. When hexose is assumed for the components of the sugar moieties, 19 to 42% of C should be assigned to sugar moieties. As the proportion of sugar moieties increased, the total N content tended to decrease. At least some portion of N could be ascribed to sugar moieties. These chemical properties were very close to those of the partial structure of mycobacterial cell walls, e.g., peptidoglycan complexed with arabinogalactan. In such cases, the N are the components of amino acids, N-acetyl glucosamines, and N-Acetylmuramic acids. To characterize the available N in the Andosol and Anthrosol, $\delta^{15}N$ values were analysed and compared among crude soils, the available organic N fractions, and N absorbed by plants (*Brassica rapa* var. perviridis and *Lactuca sativa*). The $\delta^{15}N$ values were in the following order: the available N fraction > N absorbed by plants > crude soil for the Andosol, and N absorbed by plants > the available N fraction > crude soil for the Anthrosol. This result indicates that the available N has a history of being metabolized. It is plausible that the soils available N exists as microbial metabolites, such as peptidoglycan complexed with arabinogalactan, which has been transferred from plant residues in soils.

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Title: Scaling organic carbon stocks – from microbes to landscapes

New Zealand has moderate to high levels of soil organic carbon (SOC) in part due to the temperate climate and recent conversion from native forests to agriculture. While research in New Zealand over the last decade has focused on change in SOC stocks in relation to land use and management, it is widely acknowledged that other factors such as mineralogy and microbial processes contribute to the formation and stabilisation of SOC. Here we present findings from our research projects and demonstrate the potential contribution of microbes and minerals to SOC formation that better enables interpretation and scaling to predict SOC stocks at spatial scales from paddocks to landscapes.

Many national inventories use land use as a key categorical factor when reporting change in SOC stocks. The SOC stocks in the grassland soils of New Zealand are higher than those for other land uses. The mean steady state stock (0-0.3 m depth) for managed grassland is 105.98 tC ha^{-1} compared with annual cropping (89.77 tC ha^{-1}), perennial horticulture (88.44 tC ha^{-1}) and planted forest (91.92 tC ha^{-1}). However, a proportion of these grassland soils contain Allophanic minerals with the capacity to store high SOC stocks, potentially introducing a bias in the national inventory from this land use effect. Using data from a large monitoring network across New Zealand we investigate the mineral associated organic carbon (MAOC), SOC cycling and mineralogy for soils across different land use classes to determine whether land use influences SOC when accounting for differences in mineralogy.

We examine the relationship between SOC stock, MAOC and microbial abundance along a grassland to forest gradient, within soils of the same mineralogy to demonstrate the effects of vegetation type on SOC formation and stabilisation processes. Preliminary evidence suggests that there is little difference in SOC stock (0-0.6 m depth) between grassland and forest soils challenging our underpinning assumptions.

Finally, at farm scale, variability in microbial community composition and abundance was analysed using principal component analysis showing that the variation clustered in relation to soil type despite being under the same management and vegetation. The observed variation in soil type, across the farm also corresponded to differences in SOC stock indicating that microbial composition, soil type and SOC content are more important factors such as management and vegetation type.

Data from these studies are being used to test a microbially-informed model that reveals the processes regulating SOC dynamics and allows predictions of changes in soil carbon stocks associated with land use at landscape scale.

Sam McNally

Manaaki Whenua Landcare Research

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Mineral type and land use shape formation, microbial colonization, and stability of mineral associated organic matter

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The largest share of organic carbon (OC) in soil is associated with minerals, and mineral associated organic carbon (MAOC) has typically older average ages than non-mineral bound OC. Understanding the persistence of soil OC requires therefore knowledge on the drivers of MAOC formation and stability. We expected that mineral type, as provider of reactive surfaces, and land use, as determinant of the amount and quality of adsorbable organic matter (OM), both impact the amount and longevity of mineral associated organic matter (MAOM). In order to identify the importance of different mineral types as well as land use and management for MAOM formation and stability, we exposed pristine minerals of the clay mineral illite and the iron oxide goethite for five years in permeable containers to 300 forest and grassland sites of three German regions.

Results showed that under the same environmental conditions, on average four times more MAOM formed on goethite than illite. The oxide had not only a larger capacity to bind OC, but also held stronger to MAOC as indicated by reduced desorption. The greater investment in nutrient-, particularly phosphorous (P)-, than carbon (C)-acquiring enzymes of microbial communities inhabiting goethite than illite mineral surfaces suggested that MAOM decomposition on goethite was not only limited by OC desorption, but also by nutrient availability. As a result, larger microbial biomass and mineralization (CO_2-release) rates per MAOC were observed on illite than goethite, despite regional and land-use specific differences in microbial community composition. Differences in functioning of fungal communities between minerals were probably rather attributable to saprotrophic than ectomycorrhizal fungi, since the latter were not affected by mineral type.

More OC accumulated on both mineral types under coniferous than deciduous forests, probably as a result of larger dissolved organic matter production in coniferous forests. MAOM formed on minerals below the litter layer of coniferous forests was less mineralizable than under deciduous forests. While MAOC concentrations were in a similar range for grassland and deciduous forest sites after five years of field exposure, MAOM mineralization was significantly larger in grasslands. Since no differences in MAOC desorption were observed, larger investment in nutrient and particularly P-cycling enzymes in forests than in grasslands suggest, that this was due to differences in MAOM quality. Minor shifts in microbial community structure with smaller contributions of fungi and gram-positive bacteria in grassland than in forest sites could also have contributed to larger MAOC mineralization in grasslands. Within grassland sites, nutrient availability further influenced microbial activity, with higher biomass per MAOC at fertilized sites with smaller CN ratios of the MAOM.

Our results show that minerals and land use interact in MAOM formation and stability. Even after only five study years, available sorption sites on minerals, and thus mineral types, were more limiting to MAOM accumulation than land-use driven differences in OM input to the minerals. Mineral type also affected MAOM stability by altering microbial C and nutrient acquisition, which was further modified by land use dependent changes in OM quality and accompanied shifts in microbial community composition.

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Integrating grassland species with beneficial root traits to promote soil C stabilization

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A total of 2500 gigatons of carbon (C) is stored in soils globally, surpassing the combined C content of the atmosphere and vegetation. However, this crucial C reservoir faces threats from climate change. Safeguarding and enhancing this vast C pool is paramount to mitigate positive climate feedbacks within terrestrial ecosystems, particularly in grassland ecosystems, which account for 34% of terrestrial C stocks. While root functional traits have been demonstrated to influence soil processes and ecosystem function, understanding their impact on soil organic matter (SOM) dynamics in interaction with soil microbes and the soil matrix remains limited. We aimed to investigate whether forbs and legumes, which possess advantageous root traits for microbial colonization such as high root diameter and root nitrogen content, contribute to higher C stabilization in SOM under ambient, drought and flooding conditions. To test this hypothesis, we established a mesocosm experiment featuring four plant communities with contrasting root traits: a *Lolium perenne* monoculture and three mixed communities with varying abundances of *Lolium perenne* (grass), *Cichorium intybus* (forb), *Plantago lanceolata* (forb), and *Trifolium pratense* (legume), cultivated in soils with both low (3%) and high (18%) clay content. The mesocosms were subjected to 100-year return drought and flooding events during the growing season. We found that forb- and legume-rich communities enhanced net C uptake compared to grass monocultures under ambient conditions, but not under drought and flooding. This response points to the high resistance and resilience of *Lolium perenne* to water-stressed conditions, increasing its abundance in mixed communities following the extreme events, thereby lowering net ecosystem C uptake. In addition, high clay soils displayed higher dissolved organic C, but similar microbial biomass C levels compared to those of low clay soils, likely due to small pore size in high clay soils with lower hydraulic connectivity that limited nutrient and C supply to soil microbes. Our findings suggest that prolonged drought and flooding events may lead to a dominance of grass species within mixed communities, posing a potential threat to reducing net ecosystem C uptake and attenuating both above- and belowground carbon inputs. However, the inclusion of drought- and flooding-resistant forb species, such as *Plantago lanceolata*, in productive grasslands, particularly in soils with adequate clay content, could offer a solution for enhancing belowground C sequestration. As the project progresses, we anticipate delving deeper into the intricate interplay among root-derived carbon input, microbial activity, and sorption processes, elucidating the mechanisms underlying the formation of mineral-associated organic matter (MAOM).

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A view from inside: Organic matter’s influence on iron mineral structures through the lens of Mössbauer Spectropscopy

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Organic matter is often intimately associated with iron mineral phases and this association alters the composition and reactivity of both the iron and carbon in these mineral associated organic matter (MAOM) structures. Over the past 15 years, my group has deployed Mössbauer spectroscopy to characterize organic-rich iron phases in natural soils and sediments, as well as model systems. This presentation will synthesize our findings across multiple collaborative publications as well as work from my own group to evaluate soil iron-organic coprecipitates generated either through natural processes or through careful laboratory experiments. Collectively, we find that the route of formation for the Fe-MAOM is important, with rates of formation, balance of Fe and C, as well as the degree of aging all critical determinates of the MAOM reactivity. Organic matter presence during formation nearly always decreases the crystallinity of Fe-based MAOM structures, but does not necessarily result in an unstable solid product. In natural systems, low-crystallinity, organic-rich Fe-MAOM phases are likely a persistent feature, even in highly weathered, oxic horizons. In laboratory experiments, by reacting these phases with either isotopically-labelled ^{57}Fe or ^{13}C, we are able to probe their susceptibility to exchange with aqueous phase constituents. Similarly, by subjecting them to oxidation and reduction we can probe their susceptibility to decomposition or transformation. By and large, we find that even when significant alteration or decomposition occurs, a portion of the MAOM structure persists when perturbations are carried out in complex soil matrix. In line with the theme of this ISMOM symposium, we speculate and propose that these persistent MAOM structures are composite structures composed of low-crystallinity Fe, crystalline-Fe, Al, and clays in structurally complex association with OM.

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Arbuscular mycorrhizal fungi augment carbon and nitrogen storage in soil microaggregates even under low water availability

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Structural arrangement of soil particles modulates most soil functions by regulating flows of air and water and cycling of elements. The development of soil structure and turnover of aggregates depend on many factors such as water dynamics, soil texture and mineralogy, and soil organic matter, but also the direct influence of plants and soil organisms, via the physical displacement of particles and release of organic compounds that can act as gluing agents.

Despite the complexity in disentangling the effects of these interacting factors, we aim to partition the respective influences of roots and their associated arbuscular mycorrhizal fungi (AMF) on soil aggregate development and the accumulation of soil organic matter. We intended to further affirm the ability of AMF to support plant growth and soil C turnover, particularly under reduced water availability.

To discriminate the effects of plant roots and AMF, we used *Lotus japonicus* (a wild type and two mutants: *ccamk* and *ram2-2*). The mutants allowed to restrict or suppress root colonization by AMF. We used an artificial soil mixture with a loamy texture and free of microorganisms and organic matter. Plants were grown during 60 days in a climate chamber and the watering of half of the mesocosms was stopped two weeks before the end to create soil water limitation. At the end of the incubation, we analyzed root architecture, AMF traits (intraradical colonization, hyphae length), rhizosheaths soluble fraction as well as organic C and N contents in dry-sieved aggregates for both the rhizosphere soil and the non-rhizosphere soil.

AMF colonization supported plant growth and root development, but we did not observe drastic changes in soil structure formation despite increased root length and root surface area, and the presence of fungal hyphae. We were able to identify individual organic compounds exuded around the rhizosheaths and released specifically with presence of AMF. The presence of AMF also fostered the accumulation of C and N in microaggregates in the rhizosphere soil and we also detected more C in the non-rhizosphere soil when AMF were present. The enhanced MAOM formation induced by AMF was also observed under reduced water availability, which indicates the importance of the symbiosis between the plant and the AMF to cope with water limitation and sustain soil C turnover.

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Does structure really matter? Exploring implications of microbe-structure interactions to carbon dynamics at the field scale

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Soil structure determines crucial soil physical processes, such as water distribution, gas flow, and cycling of carbon and nutrients. This way, it builds and constrains biological habitats. The resulting environmental conditions at the micro- or mesoscale builds and constrains habitats for plants, soil fauna, and microorganisms. However, the direct impact of soil structure on these biological actors remains poorly understood. So far, research primarily focused on mechanisms at the aggregate or pore scale. Although process knowledge on this scale is still needed, it is also essential to understand the implications of such interactions for soil functions at the field scale.

Within this study, we tested different concepts of microbe-structure interactions using the systemic soil model BODIUM (König et al., 2023; bonares.de/bodium), and analysed the consequences for carbon dynamics at the field scale.

Our model integrates a dynamic soil structure with distinct pore size classes and explicit representation of microorganisms, recently extended to distinguish between bacteria and fungi. This framework allows us to explore microbe-structure interactions, by adjusting fungi and bacteria mobility, growth strategies as well as microbe and carbon distributions within the pore size classes. The evaluation of the soil structure is supported by the Soil Structure Library (Weller et al., 2022; https://structurelib.ufz.de/lit/), which provides a collection of analysed soil CT images with pore size distributions down to 10 µm. For some of the images additional information was obtained on the distribution of particulate organic matter and its correlation with the pore system. This allows further process analysis on aerobic and anaerobic matter turnover.

We performed simulations spanning temporal and spatial scales relevant to agriculture, and analysed the implications for soil total soil carbon and C to N ratio, the proportions of fungi and bacteria, as well as emission rates. Additionally, we simulated scenarios involving tillage and bioturbation, which alter soil structure, to account for soil structure dynamics and resulting spatial distribution of organic matter.

Our simulation results suggest that soil structure indeed exerts a significant influence on field-scale soil functions, but rather by shaping environmental conditions for microbes and not due to direct interactions. However, the extent of this influence critically depends on our assumptions for the mobility and growth behaviour of microorganisms. This dependency also suggests that in our scenarios soil structure is not a limiting factor, and we should extend our simulations to more extreme scenarios such as a high compaction.

Consequently, further modelling and experimental research is needed to unravel the underlying mechanisms and develop robust upscaling approaches.

König, S., Weller, U., Betancur-Corredor, B., Lang, B., Reitz, T., Wiesmeier, M., Wollschläger, U., Vogel, H.-J. (2023): BODIUM - a systemic approach to model the dynamics of soil functions. Eur. J. Soil Sci. 74 (5), e13411, 10.1111/ejss.13411

Weller, U., Albrecht, L., Schlüter, S., Vogel, H.-J. (2022): An open Soil Structure Library based on X-ray CT data. Soil 8 (2), 507 – 515, 10.5194/soil-8-507-2022

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Distribution of microbial metabolic power in the soil pore network

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Soil microbial communities live within a complex three dimensional pore network, the properties of which constrain microbial activity. The physical structure of the pore network limits microbial access to resources. It also affects the micro-environmental conditions (e.g. redox conditions, pH) that can affect microbial use of the available resources and the rates at which they use energy. Whilst the distributions of different types of activities (CO_2 production, enzyme activities) in the pore network have received some attention, the rate at which microbial communities use the energy available to them, i.e. metabolic power, has not been studied in any great detail. However, energy is required for most aspects of microbial functioning and the rate at which this energy is used determines the extent to microbial activity and growth proceed.

Linking the energy available to the rate at which it is processed at the pore scale may help us to better understand how microbial growth and C dynamics are constrained by the physical environment in soil. In order to do so, we added isotopically-labelled organic substrate to pores with different neck diameters and measured microbial catabolic rates and the associated Gibbs energies of the reactions. This allowed us to estimate the distribution of microbial metabolic power in the pore network and of carbon use efficiency. We then compared the distributions of metabolic power with those of carbon use efficiency at the pore scale.

Mineral and substrate control on MOM formation efficiency, and feedbacks to microbial composition and function

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Mineral-associated organic matter (MOM) plays an important role for organic matter persistence in soils with turnover times of decades to millenia. It is currently assumed that microbial necromass contributes significantly to MOM formation. Differences in the processing and stabilization of microbial versus plant residues are still unresolved. We studied on how substrate quality (bacterial necromass, *Bacillus subtilis*, C:N=3.7; fungal necromass, *Aspergillus niger*, C:N=12.5; maize litter, Zea mays, variety *Yucon Chief*, C:N=15.4), and mineral type (iron oxide goethite, α-FeOOH, SSA=15.4 m^2 g^{-1}), clay mineral illite (SSA=34.6 m^2 g^{-1}), and quartz sand) influence substrate decomposition and MOM formation, and how mineral-OM interactions feedback to microbial community composition, their carbon use efficiency (CUE), and enzyme activities in a one month incubation.

Our results show that substrates and minerals both influence decomposition by changing the microbial community composition and its functioning. Minerals with higher sorption capacity reduced decomposition rates and microbial biomass, increased activities of extracellular enzymes involved in C-, N-, and P-cycling, and shifted microbial community composition. Among the added substrates, bacterial necromass, being nutrient rich, decomposed fastest. At the end of the incubation, mineral-substrate mixtures with bacterial necromass had the smallest microbial biomass, CUE, activities of extracellular enzymes involved in C- and P-cycling, and a less diverse microbial community than samples were maize litter of fungal necromass were added. Since also the effect of mineral type on substrate decomposition was absent for bacterial necromass, we find no evidence for preferential stabilization of bacterial necromass by minerals so far, though results of the density fractionation of the samples to determine MOM formation are still pending. Our results highlight that fresh surfaces of secondary minerals in soils are no inert background, but modifying decomposition rates by shifting microbial substrate availability, community composition and functioning.

The effects of spontaneous cover crops on soil aggregation in Mediterranean orchards.

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As intensive farming threatens soil functionality, a critical factor for sustainable food production, sustainable land management (SLM) practices offer a powerful tool to combat this degradation. One of the most promising SLM practices is the use of cover crops. This study investigated the impact of naturally occurring cover crops on the formation of soil aggregates in Mediterranean orchards, including olive and fruit trees. Twelve farms with two different treatments were established in SE Spain: 6 farms with spontaneous cover crops (CC), and 6 farms with traditional management with intensive tillage, keeping alley soil bare (TR). Soil was sampled at 0-30 cm and analysed for stable aggregate fractions, mean weight diameter for aggregates (MWD), particle size distribution, bulk density, coarse fragments, particulate organic carbon (POC), total organic carbon (TOC), total nitrogen, carbonates and enzyme activities. We performed lineal regression models with MWD as dependent variable and the rest of soil properties as independent variables, independently for each treatment. Results showed that there were no significant differences between treatments in MWD, with an average value of 0.49 mm. Both regressions models were accurate to estimate MWD, with $R^2 = 0.89$ and F-value = 23.90 ($P < 0.01$) for CC, and $R^2 = 0.82$ and F-value = 13.15 ($P < 0.01$) for TR. Partial correlations of the model showed that for CC orchards, MWD was positively and strongly associated with coarse fragments, enzyme activities and POC, while negatively associated with carbonates content and TOC. For TR orchards, partial correlations showed that MWD was positively and strongly associated with coarse fragments, and POC, while negatively associated with carbonates. Thus, these results highlight the importance of coarse fragments to protect soil to foster the formation of stable aggregates, and particulate organic carbon, which can favour the formation of large stable aggregates by stimulating microbiota as a source of nutrients. Moreover, only in soils with CC, MWD was strongly associated with enzyme activities, suggesting the stimulation of soil microbiota with the development of spontaneous CC, not observed in those soils that are kept bare. These findings emphasize the importance of the adoption of CC in Mediterranean orchards to stimulate soil microbiota, which can enhance the formation of stable aggregates.

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Stability of mineral-associated organic matter in soils depends on mineral type and land use

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Phyllosilicate clays and iron oxides are regarded as essential mineral groups involved in the long-term stabilization of organic matter (OM) in soils. However, their individual contributions to this process and the susceptibility of their associated OM to microbial decomposition under different land uses remains unclear. Here, we assessed the stability of OM that accumulated on pristine goethite (iron oxide) and illite (phyllosilicate clay) after five years of exposure in topsoils at 68 forest and grassland sites across Germany. During the five years of field exposure, goethite accumulated significantly more organic carbon (C) than illite (on average 0.21 ±0.09 and 0.05 ±0.02 mg m^{-2} mineral surface respectively). However, the release of CO$_2$ per gram mineral-associated OM-C (MAOM mineralizability) was about two times lower for goethite than illite during incubation under standard laboratory conditions (20°C, 60% water holding capacity). Microbial biomass per unit MAOM was also lower on goethite than illite. This indicates slower cycling, and thus, a higher stability of goethite- than illite-associated OM. Slower cycling of goethite-associated OM likely results from stronger binding of OM by goethite, and in turn, a lower bioavailability of OM on goethite than illite. Strong binding of phosphate by goethite may add to the hampered mineralizability of goethite-associated OM by imposing phosphorus limitations on the activity and growth of microorganisms inhabiting the mineral's surface. Higher MAOM mineralizability in grasslands than in forests reflected greater nutrient constraints and lower abundance of gram-negative bacteria in forests. The difference in MAOM mineralizability between forests and grasslands was greater for illite than goethite. These findings demonstrate that MAOM—the so-called persistent fraction of soil OM— is responsive to land use-induced changes in soil conditions, and implicates soil mineral composition as a crucial modulator of this response.

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Soil warming and rain exclusion promote stable soil mineral-organic associations in dryland soils

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Drylands collectively form the largest biome on Earth and store 32% of the global soil organic carbon pool. Their importance will increase in the future, as recent studies indicate that the extension of global drylands will increase by 10% at the end of this century due to ongoing climate change. Previous studies have shown an enhanced sensitivity of soil respiration in drylands to changes in both soil temperature and moistureXXXX. At the same time, the importance of organo-mineral associations as a mechanism to selectively preserve soil organic matter (SOM) can increase, due to the formation of more stable Ca mediated associations. It is thus imperative to improve our understanding on how the molecular composition of soil organo-mineral associations will be affected by climate change in these areas. We leveraged samples from the Aranjuez Experimental Station (40°02′N–3°32′W; elevation = 590 m a.s.l.; climate: Mediterranean semiarid; MAT: 16.5°C and MAP: 336 mm; Soil type: Gypsiric Leptosol), where an ongoing experiment explores the effects of warming (W), rain exclusion (RE), and its combination (WW+RE) on dryland ecosystems. We fractionated each treatment into bulk soil, light fraction (LF) and mineral associated (MAOM) fraction and analysed each treatment for its OC, IC, ^{13}C NMR, bulk C, N and Ca NEXAFS and used scanning transmission X-ray spectromicroscopy (STXM) at the C, N and Ca edge for the MAOM fraction. Relative to control plots, the bulk OC and the light fraction decreased 10% and 2% for the W treatment and increased 33% and 47% in the W+RE treatment, respectively. At the LF, there was an increase of relative contribution of protein by 20% (W), 12% (RE) and of carbonyl by 50% (W), 30% (RE). The MAOM STXM C K-edge data shows a relative enrichment of phenolic and carboxylic C for the W and W+RE treatments, while the Ca L-edge data shows an increase of Ca-org. and $CaCO_3$ for the W and W+RE treatments. Overall, the increase of OC in the bulk soil of the W+RE treatment reflects the enrichment of organic polar compounds which are stabilized through Ca-organic associations and further stabilized by cementation by $CaCO_3$.

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Rechargeable biogenic mineral induced by a sulfate reducing bacterium enhances microbial community activities

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Relationships between microbes and minerals in environments are unknown yet. Sulfate reducing bacteria are one of representative microbes under anaerobic environments and contributes to sulfur and carbon recycle on the Earth. A sulfate reducer isolated from lake sediments produced black precipitates. Electrochemical and material scientific analyses revealed that the black precipitate is rechargeable mackinawite (RBM). RBM was converted to lepidocrocite under discharged condition with amorphous iron oxides. To investigate effects of RBM on microbial activities, enrichment cultures were anaerobically constructed with RBM, sediments, and lactate as sole electron donor (RBM cultures). The RBM cultures exhibited higher lactate and acetate-degrading rate with higher methane-producing rate compared with control cultures constructed without RBM. Multidimensional scaling analyses using 16S rRNA gene amplicon sequences showed that microbial community structures had developed differently in control and RBM cultures. These results suggest a hypothesis that some microbes were electrically connected via RBM. To investigate this hypothesis, bacteria related to forming bacterial communities were obtained from the RBM cultures. Electrochemical analysis revealed that obtained strains and a methanogen exhibited extracellular electron transfer activity and extracellular electron uptake activity, respectively. Furthermore, these microbes would be connected electrically via RBM. These results suggested that rechargeable minerals play roles in electron donor/acceptor/pools and microbial community activities are enhance by forming electrically microbial symbiosis.

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Micro-scale approach to quantitative analysis of enzymatic activity in soils

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Most bio-geochemical reactions, including enzymatic, in the soil occur at microscales. Due to high soil heterogeneity and different affinity of enzymes to surfaces of soil clay, silt, and sand fractions, the activity of hydrolytic enzymes can vary greatly even within a small soil volume. Traditional enzymatic analysis uses highly diluted soil suspensions with temperature and pH levels optimized for potential enzymatic activity in bulk soils. However, potential activity tends to overestimate that in the soil, because of not-optimal environmental conditions (i.e. local pH, water content, soil aggregation) prevail at most micro-sites. In this study we developed and tested a new approach for measuring activity of two hydrolytic enzymes (i.e. β-glucosidase and acid phosphatase) on the surface of soil particles. The approach is an extension of recently developed time-laps zymography (TLZ). TLZ approach requires a substrate saturated membrane to be incubated on the soil/root surface, while the signal development is registered in the membrane using a time-laps imaging. The new procedure is based on a direct application of the substrate to the soil and modeling of the product diffusion to the membrane. The diffusion coefficients and redistribution of the product between the soil and the membrane were obtained for 4 soils with contrasting soil texture by combining the product diffusion experiments with modeling using HP2 software. Then TLZ at a spatial resolution of 17 mm was conducted for the same soils taken from plots with contrasting vegetation (i.e. switchgrass and restored prairie) of Marginal Land Experiment - Great Lake Bioenergy Research Center, USA to quantify the probability distributions of b-glucosidase and acid phosphatase activity on the soil surface. The results showed high variability of enzymatic activity in all soils for the two vegetations. The coefficients of variation (CV) ranged from 0.16 to 0.48 and were the smallest and the largest for β-glucosidase in a sandy loam soil under switchgrass and a restored prairie, respectively. Soil properties affected mean values of enzymatic activity in all treatments except β-glucosidase in the restored prairie. The mean activity of b-glucosidase and acid phosphatase increased with soil pH, silt, and clay contents, while decreased with sand, total carbon and total nitrogen contents. The effect of soil properties on CV was observed only for b-glucosidase in the restored prairie. Overall, the developed approach enables quantification of the probability distributions of enzymatic activity on the soils surface at the resolution comparable with size of soil pores and soil particles.

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Resolving microbe-mineral-organic matter interactions in soils and sediments using photothermal infrared microscopy

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Abstract

Interactions among microbes, minerals, and organic matter are key controls on carbon, nutrient, and contaminant dynamics in soil and sediments. However, probing these interactions at relevant scales and through time remains an analytical challenge due to both their complex nature and the lack of tools permitting non-destructive time-step analysis. The recent development of optical photothermal infrared (O-PTIR) microscopy has opened the way for non-invasive analysis of these interactions at submicron resolution through time. Here we demonstrate the ability of O-PTIR microscopy to analyze mineral-organic microstructures down to 500 nm, without contact, allowing the time-resolved, non-destructive characterization of both mineral and organic components. Our results showed that by employing appropriate laser powers, O-PTIR microscopy allows the identification of all minerals and organic matter. We demonstrated that organic matter, particularly low-molecular-weight organic compounds, may be more prone to detection than minerals, then enhancing the identification of organic compounds within mineral matrixes or mineral surfaces. Moreover, the localization of mineral-bound and unbound organic matter was achieved down to the microscale. Our results highlight the potential of O-PTIR microscopy to resolve microbe-mineral-organic matter interactions in soil and sediments (Fig.1).

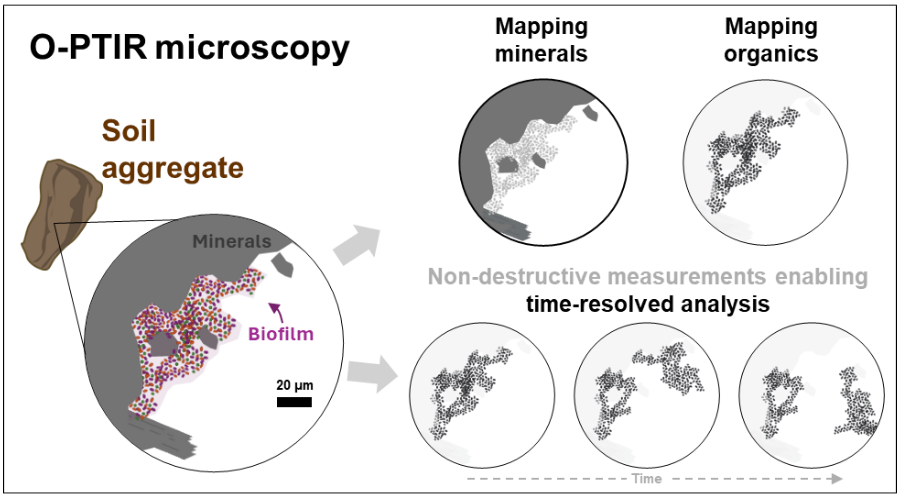

Fig. 1. Conceptual diagram of O-PTIR's potential for resolving microbe-mineral-organic matter interactions in soils.

Correlative imaging of the rhizosphere – A multi-method workflow for targeted mapping of chemical gradients

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Examining *in-situ* processes in the soil rhizosphere requires spatial information on physical and chemical properties under undisturbed conditions. We developed a correlative imaging workflow for targeted sampling of roots in their 3D context and assessing the imprint of roots on chemical properties of the root-soil contact zone at µm to mm scale. Maize (*Zea mays*) was grown in ^{15}N-labelled soil columns and pulse-labelled with $^{13}CO_2$ to visualize the spatial distribution of carbon inputs and nitrogen uptake together with the redistribution of other elements. Soil columns were scanned by X-ray computed tomography (X-ray CT) at low resolution (45 µm) to enable image-guided subsampling of specific root segments. Resin embedded subsamples were then analysed by X-ray CT at high resolution (10 µm) for their 3D structure and chemical gradients around roots using micro X-ray fluorescence spectroscopy (µXRF), nanoscale secondary ion mass spectrometry (NanoSIMS), and laser-ablation isotope ratio mass spectrometry (LA-IRMS). Concentration gradients, particularly of calcium and sulphur, with different spatial extents could be identified by µXRF. NanoSIMS and LA-IRMS detected the release of ^{13}C into soil up to a distance of 100 µm from the root surface, whereas ^{15}N accumulated preferentially in the root cells. We conclude that combining targeted sampling of the soil-root system and correlative microscopy opens new avenues for unravelling rhizosphere processes *in situ*.

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Metal-organic carbon interactions in wetlands: Implications for wetland carbon preservation

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Wetlands (including peatlands) are global hotspots for carbon storage, which is conventionally attributed to the inhibited microbial decomposition. However, as one of the key mechanisms promoting soil organic carbon (SOC) persistence, metal-organic interactions in wetlands remain under-investigated. By employing mesocosm manipulations and large-scale investigations, our research has revealed that wetlands (especially mineral-rich wetlands) harbor abundant reactive metal species where OC associated with reactive (i.e., poorly crystalline or short-range-ordered) iron (Fe) and aluminum (Al) oxides (bound OC) constitutes a sizable fraction (up to 40%) of SOC. Further evidence indicates that reactive metal (e.g., Fe) oxides override silicate clay in SOC association, emphasizing the dominance of metal oxides in wetland SOC protection. In particular, *Sphagnum* wetlands are a remarkable reservoir of bound OC among all terrestrial ecosystems via activating Fe and Al oxides in the soil. Furthermore, our findings suggest that while wetland drainage may enhance microbial decomposition under oxygen exposure, an alternative pathway, i.e. protection of SOC by newly-formed reactive Fe oxides through ferrous iron oxidation, may promote the stabilization of wetland SOC (the ‘iron gate’ mechanism), especially in soils with high contents of oxidizable Fe. These findings collectively highlight the importance of metal-organic carbon interactions in the long-term preservation of wetland carbon.

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Unraveling the effect of soil aeration on soil organic carbon mineralization in soils with different tillage intensity

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Preserving soil organic carbon (SOC) stocks in agricultural soils is essential for climate change mitigation, yet the intricate relationship between soil aeration, tillage intensity, and SOC stabilization remains poorly understood. This study aims to systematically investigate this relationship by examining soil samples from a long-term experiment in Switzerland involving conventional and non-tillage practices across clay and loam soils. The objectives are to elucidate how soil aeration influences SOC mineralization and stabilization and to inform the development of sustainable tillage practices for organic carbon sequestration in agricultural soils.

We hypothesize that tillage intensity will induce macroporosity formation and enhance oxygen diffusion, thereby accelerating SOC mineralization rates and reducing SOC stocks over the long term. Additionally, we expect finer-textured soil to restrict macroporosity and oxygen diffusion, leading to a higher prevalence of anoxic microsites, which may limit SOC mineralization and potentially result in higher SOC contents over time.

To address these hypotheses, we determine bulk SOC concentrations, and oxygen levels are being measured using a planar optode approach coupled with sandboxes. This enables the observation of anoxic microsites under different tillage practices and soil textures across various soil matric potentials. These measurements are correlated with CO_2, N_2O and CH_4 emissions to assess their relationship with soil aeration metrics and SOC mineralization. Additionally, X-ray µCT scanning are utilized to quantify pore characteristics such as connectivity and turtuosity, while another batch of intact soil core measurements provides insights into oxygen diffusion properties and pore size distribution.

In conclusion, this study provides a systematic understanding of the interplay between tillage practices, soil aeration, soil structure, and SOC stabilization. By shedding light on how tillage practices affect soil aeration and subsequently SOC dynamics, this research aims to contribute to the understanding of soil aeration as a mechanism of SOC mineralization and stabilization and to the development of sustainable tillage practices for enhancing organic carbon sequestration in agricultural soils.

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Earthworms enhance plant-derived OM stabilization through mineral interactions: effects of species and soil types

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Abstract: Earthworms impact soil organic matter (SOM) formation by incorporating plant litter into their casts as particulate and mineral-associated organic matter (POM and MAOM). While the protection of POM inside casts is well-known, the importance, source, and composition of cast MAOM, especially across different species and soil types, remains poorly understood. To address this gap, our study employed ^{13}C labeling and biomarker analyses to investigate the composition and origin (plant or microbial compounds) of MAOM in fresh casts produced by three temperate earthworm species—*Lumbricus castaneus* (LC), *Lumbricus terrestris* (LT), and *Allolobophora icterica* (AI). Our conceptual approach included cast production using ^{13}C-labeled litter and two soil types (an Alluviosol and a Cambisol) under controlled laboratory conditions. We analyzed elemental and stable isotope composition, and determined the neutral sugar and lignin signatures. The results demonstrated that earthworms stimulated MAOM-C formation in the order LC > LT > AI. Stable carbon isotope tracing revealed that newly-formed MAOM-C was mainly derived from litter, with litter-derived C contributions to MAOM-C varying between 18% and 68%. The sugar and lignin contents of cast MAOM were higher than those of soil. In Alluviosol, LC casts exhibited the highest sugar and lignin enrichment (7.6-fold and 5.5-fold, respectively) relative to soil, followed by AI and LT. Conversely, in Cambisol, LC-cast MAOM showed less pronounced sugar enrichment (2.6-fold) compared to AI and LT species, while lignin enrichment remained consistent at 2.6-fold regardless of species. These findings highlight that earthworm activities lead to direct stabilization of plant litter-derived OM through mineral interactions, with variations driven by earthworm species and soil type.

Key words: Soil fauna; neutral sugars, lignin; soil types; organ-mineral complex; casts

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The ultimate stabilisation: making the organic mineral. The case for irrigated gypsum-rich soils.

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There is evidence that agricultural management can generate changes in the dynamics of soil carbonates (Plaza-Bonilla et al. 2015), which can be reflected both in the final balance of carbonates in the superficial layers (Zamanian et al., 2021; de Soto et al., 2017) and in the ratio of pedogenic vs. lithogenic carbonates (de Soto et al., 2019). This is so because agriculture can interact in the dissolution and (re)precipitation of carbonates.
This transfer of carbon from the organic to the mineral fraction can be considered a true atmospheric C stabilization in the form of carbonates depending on the origin of HCO_3^- and Ca^{2+} in the reaction (Sanderman, 2012). If the HCO_3^- is supplied from the dissolution of biologically-derived soil CO_2, such as that released by organic matter decomposition, and Ca^{2+} comes from non-carbonate or exogenous sources, the so-called *pedo-atmogenic* carbonates are formed (Monger and Martínez-Ríos, 2001). The dissolution of gypsum ($CaSO_4 \cdot 2H_2O$) is one of these sources (Laudicina et al., 2021), and in agricultural soils, it can be accelerated when the soil water regime is altered by irrigation:

$$CaSO_4 \cdot 2H_2O + CO_2 + H_2O \rightarrow CaCO_3 + SO_4^{2-} + 2H^+ + 2H_2O$$

This reaction would lead to a local acidification and decarbonation of microsites in the soil and a substitution of gypsum by calcite, a feature which has been observed in gypsum-rich soils as calcite pseudomorphs after gypsum (Poch et al., 2018).

In this study, we conducted a two-step approach to quantify the extent of atmospheric C incorporation into soil carbonates in areas with gypsum-rich soils upon the adoption of irrigation. First, we studied the effect of the transformation to irrigation of two watersheds in Navarra and Catalonia (Spain) with gypsum-rich soils on the dissolution of gypsum, by monitoring the sulfate content in the river draining the watershed before and after several years of irrigation. We observed a clear gain in sulfates concentration in draining water after the adoption of irrigation, in the months when it is used intensely.
Second, we conducted a pot experiment designed ad-hoc to quantify the amount and typology of carbonates formed as a consequence of this process. To that end, we set an experiment in which a

gypsum-free loess-derived topsoil was mixed with pure gypsum at different concentrations (0% - 5% - 50% - 80%) and two plant species: *Oxalis* sp. (oxalogenic) and *Brassica* sp. (root calcifying plant) were grown for three months at 25 ºC with 16 hours of light and 8 of darkness and a humidity between 60 and 100% of the field capacity. The amount of total and active (clay-size carbonates) were monitored, as well as the $\delta^{87/86}$Sr and the Sr^{2+}/Ca^{2+} ratios of carbonates (indicators of the origin of Ca^{2+}). A micromorphological description and digital quantification of calcitic pedofeatures were conducted from soil thin sections. Results indicate an effect of the gypsum content in the formation of pedogenic carbonates, suggesting a net transfer of C from soil organic matter to soil carbonates, and therefore setting the basis for additional C-sequestering strategies in these soils.

Plaza-Bonilla D, Arrúe JL, Cantero-Martínez C, Fanlo R, Iglesias A, Álvaro-Fuentes J. Carbon management in dryland agricultural systems. A review. *Agron Sustain Dev*. 2015;35(4):1319-1334. doi:10.1007/s13593-015-0326-x

Zamanian K, Zhou J, Kuzyakov Y. Soil carbonates: The unaccounted, irrecoverable carbon source. *Geoderma*. 2021;384(September 2020):114817. doi:10.1016/j.geoderma.2020.114817

de Soto IS, Virto I, Barré P, et al. A model for field-based evidences of the impact of irrigation on carbonates in the tilled layer of semi-arid Mediterranean soils. *Geoderma*. 2017;297:48-60. doi:10.1016/j.geoderma.2017.03.005

de Soto IS, Virto I, Barré P, Enrique A. Effect of irrigation on carbonate dynamics in a calcareous soil using isotopic determinations. *Spanish J Soil Sci*. 2019;9(2):142-147. doi:10.3232/SJSS.2019.V9.N2.06

Sanderman J. Can management induced changes in the carbonate system drive soil carbon sequestration ? A review with particular focus on Australia. *Agric Ecosyst Environ*. 2012. doi:10.1016/j.agee.2012.04.015

Monger, C. H. and Martínez-Ríos, J. J. (2001). Inorganic C sequestration in grazing lands. In: Follett, R. F., Kimble, J. M. and Lal, R. (Eds) *The Potential of US Grazing Lands to Sequester Carbon and Mitigate the Greenhouse Effect*. Boca Raton, FL: Taylor & Francis, pp. 87–117.

Laudicina VA, Dazzi C, Delgado A, Barros H, Scalenghe R. Relief and calcium from gypsum as key factors for net inorganic carbon accumulation in soils of a semiarid Mediterranean environment. *Geoderma*. 2021;398(March):115115.

Poch RM, Artieda O, Lebedeva M. Gypsic features. In: Stoops G, Marcelino V, Mees F., eds. *Interpretation of Micromorphological Features of Soils and Regoliths*. 2nd. Elsevier; 2018:259-287.

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Moisture-driven relationships between soil organic carbon and short-range ordered minerals at the global scale

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An important control on long-term soil organic carbon (SOC) storage is the protection of SOC from decomposition by short-range-ordered (SRO) minerals. SRO minerals are commonly quantified by measuring oxalate-extractable aluminum (Al_{ox}) and iron (Fe_{ox}) in soils, which many studies have shown to be positively correlated with SOC. Uncertainties remain, however, as to whether the relationship between SRO minerals and SOC is a global one, or whether regional differences need to be considered to improve model accuracy. Here, we present a global synthesis of Al_{ox} and Fe_{ox} to test whether they can be used as proxies for SOC abundance across regions. We compiled over 37,300 individual measurements, with soil depths ranging from 0 to 200 cm, from approximately 11,100 soil profiles. We used the Holdrige Life Zones, which are characterized by biotemperature, precipitation and potential evapotranspiration, to group the soil profiles according to climatic conditions. Based on linear mixed-effects models, we found a positive relationship between Al_{ox}, Fe_{ox} and SOC across regions and depths, accounting for 43% of the variation in SOC. Interestingly, Al_{ox} and Fe_{ox} are better predictors of SOC when the data are disaggregated into climatic regions, and the relationships are stronger in wetter regions and at depths between 20 and 100 cm. This relationship tends to be independent of temperature. Our analysis shows that Al_{ox} and Fe_{ox} are good proxies for mineral-induced SOC protection at the global scale. However, our findings also indicate that the importance of organo-mineral interactions at the global scale varies with climatic conditions and depth. The underlying mechanisms need to be considered when incorporating this relationship as a proxy for SOC abundance into soil C models.

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The roles of basalt particle size on carbon sequestration in rock-plant residue mixtures: possible trade-off between CO_2 removal and organic C accretion

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Enhance Rock Weathering is one of the potential strategies for remediating global warming effects. Previous theoretical calculations showed smaller particle size has a higher carbon dioxide removal (CDR) rate due to a larger surface area. However, the CDR rate of smaller basalt can be hindered in soils by its interaction with organic matter (OM), which, on the other hand, can potentially contribute to OM stabilization. Our study thus aimed to evaluate the effect of basalt particle size on CDR and OM retention in a basalt-plant residue (POM, crushed potato leaf)-quartz mixture. Two sizes of basalt (small: 20 – 38 μm, large: 106 – 150 μm) with and without POM were leached weekly with artificial rainwater (pH=4.7) and inoculated with natural soil microbial community every two weeks under two regimes of wet/dry cycles for six months and collected leachates. After six months, the subsamples were analysed for total C contents and for extractable Si, Al, Fe, and Mn by pyrophosphate, oxalate, and dithionite-citrate reagents.

The density fractionation showed that the small basalt treatment formed greater amounts of meso-density, organo-mineral aggregates (1.8 – 2.4 g cm^{-3}) than the large basalt treatment, which indicated a higher potential of the small basalt to retain POM-derived C through organo-mineral interaction. Despite the higher surface area, the small basalt released a similar amount of Ca and Mg in the leachates compared to the large basalt in the sixth month, suggesting a similar capability in sequestrating inorganic C. Furthermore, the large basalt treatment held more extractable Fe and Mn after six months, implying greater formations of secondary minerals. These results suggest that small particle size can lead to a greater degree of organo-mineral aggregation, which likely increases OM retention while potentially hinder basalt weathering. Larger basalt, on the other hand, can have faster weathering and potentially sequestrate more inorganic carbon in the long run. We will further evaluate these ideas by microscopic and spectroscopic approaches and by examining carbonate precipitation.

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Climate change induces rapid losses of occluded particulate organic carbon in Alpine grassland soils

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Climate warming is more severe in Alpine and pre-alpine grassland soils compared to lowland regions. In our study we assessed the effect of warming (+1°C, +2°C, and +3°C) on i) the quantity and the quality of the OC, ii) changes in the different density fractions (fPOM: free particulate organic matter; oPOM >20 µm; oPOM< 20µm (occluded particulate organic matter), MAOM (mineral associated organic matter) corresponding with different functional pools of soil organic matter; and ii) on the microbial community in grassland soils of the Northern Limestone Alps in Germany. We translocated plant-soil mesocosms from high (1260 m a.s.l.) and medium elevations (860 m a.s. l.) to low elevation (600 m a.s.l.). Our experimental design combined site re-location and altitude translocation allowing differentiating between the effects of soil manipulation and climate change. In addition, two different grassland management practices: i) extensive (2 cuts for hay and 67 N kg ha-1 yr-1 slurry application); and ii) intensive (4-5 cuts for hay and 170 N kg ha-1 yr-1 slurry application) were carried out on translocated mesocosms. Four years of warming induced by translocating plant-soil mesocosms along an elevation gradient in Alpine and pre-alpine grassland soils resulted in a rapid decrease of SOC and N stocks (24-25%), particularly under extensive grassland management. These losses were associated with a reduction mainly in the oPOM< 20µm fraction, representing the most OC physically protected under extensive and intensive management. In addition, the N-O-alkyl-C compounds and the bacteria and fungi decreased with the warming only under extensive management practices. Whereas the OC related to the MAOM represent the higher amount of carbon respect to the bulk soil in both management practices. However, intensive management practices with higher manure C return than extensive management only slightly offset the losses of SOC in the plant-soil. Our results evidence that climate change may have severe consequences for the soil structure and thus for the physico-chemical protective capacity of mountainous grassland soils to store SOM. We propose oPOM< 20µm and MAOM as early warming indicators for SOM and soil structure losses.

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Soil aggregate formation, stability, and associated carbon accumulation as influenced by diversified organic amendment-derived dissolved organic matter

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Although soil organic matter (SOM) is a significant contributor to aggregate formation and stability, as well as carbon (C) accumulation, little information has paid attention to the important role of dissolved organic matter (DOM) in soil aggregate formation, stability, and associated C accumulation. To provide a better understanding of such matters, water-extractable organic matter (WEOM), a potential source of DOM from various organic amendments (OAs), and their functionality on aggregate formation, stability, and associated C accumulation were investigated through a model experiment. The WEOM samples were obtained from bark compost (BC), coffee residue compost (CRC), cattle manure compost (CMC), sewage sludge compost (SSC), fish cake (FC), and rapeseed oil cake (ROC) and characterized using high-performance size exclusion chromatography and ^{13}C nuclear magnetic resonance and diffuse reflectance infrared Fourier transform (DRIFT) spectroscopies. Upland field soil was packed in glass columns, and each WEOM solution or ultrapure water (Control) was applied repeatedly for a 30-day period. After incubation, aggregate size distribution (>2000, 500–2000, 250–500, 53–250, and <53 μm) was measured, and aggregate stability indices, i.e., mean weight diameter (MWD) and geometric mean diameter (GMD), were computed. An aggregate-associated C was determined using a CN-corder or an elemental analyzer. The application of WEOM promoted the distributions of soil mass and soil organic C (SOC) into the > 2000 μm aggregate fraction compared to the Control treatment, and the ROC-, CRC-, and SSC-WEOM treatments resulted in greater MWD and GMD than the Control and/or other WEOM treatments. The % *O*-alkyl C (29–59% of total C) and the relative abundance of high-molecular-weight (HMW) fraction (>10 kDa; 2.3–7.1% of total) in WEOM correlated positively with the proportion of > 2000 μm aggregate fraction. The relative abundance of the HMW fraction also correlated positively with MWD. The amount of SOC in the > 2000 μm fraction was significantly higher in the WEOM treatments (1.2–2.8 mg C g^{-1}) than in the Control treatment (0.4 mg C g^{-1}), except for the FC treatment, and to a large extent in the CRC treatment. The % *O*-alkyl C in WEOM also correlated positively with the amount of SOC in the > 2000 μm fraction. Overall, the findings herein suggest that the high amounts of polysaccharides, suggested by % *O*-alkyl C and supported by DRIFT spectra, and/or other HMW components are desirable structural characteristics of WEOM for promoting macroaggregate formation and aggregate stability, as well as C accumulation in macroaggregate.

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Carbon Dynamics and Sequestration in *Semen Euryales* Pond Ecosystems: Insights from the Lower Xijiang River Basin

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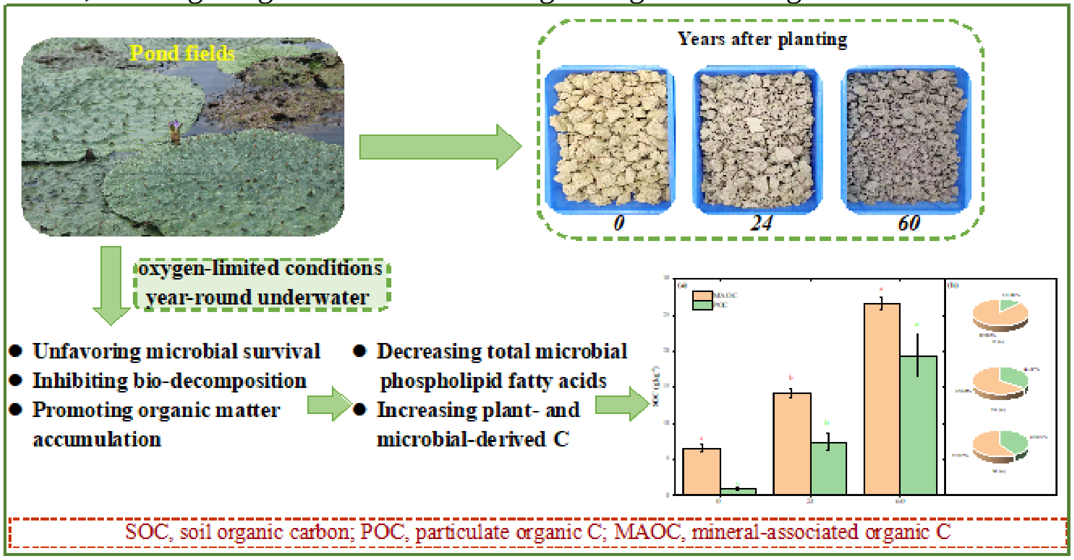
Abstract: Agri-ecosystems, notably flooded fields, are pivotal in global carbon (C) dynamics. Despite extensive research on C sequestration in paddy fields, little attention has been given to pond fields characterized by year-round waterlogging. This study investigates C source and storage in pond fields in the Xijiang River's lower reaches. Soil samples from ponds planted with *Semen Euryales* for 0, 24, and 60 years reveal a progressive increase in soil organic C (SOC), driven by both particulate organic C (POC) and mineral-associated organic C (MAOC). Notably, MAOC dominates SOC composition (58.0%–87.8%), while POC shows significant increments (12.0% to 42.0%) over time (0–60 yr). Consistent with POC and MAOC trends, lignin phenols (biomarkers of plant residue) increase from 11.0% to 68.8%, whereas amino sugars (microbial residue biomarkers) decrease from 89.0% to 31.2%, indicating a heightened contribution of plant residue to SOC over time. Moreover, total microbial phospholipid fatty acids (PLFAs) decrease by 37.3% and 36.0% after 24 and 60 years, respectively. These findings suggest that anaerobic conditions in the ponds are detrimental to microbial survival, particularly fungi, as evidenced by the decline in glucosamine, thereby impeding microbial decomposition and fostering an increase in microbial residues. The former contributes to POC formation, while the latter facilitates MAOC accumulation. This study's outcomes inform the management of *Semen Euryale* ponds for C sequestration, offering insights into climate change mitigation strategies.



SOC, soil organic carbon; POC, particulate organic C; MAOC, mineral-associated organic C

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Poster session

Session 1:

Fundamental aspect of ISMOM: challenges & opportunities

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Effects of microbial functional traits on soil organic matter composition and persistence

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Molecular diversity is believed as a key-driver of soil carbon persistence, since a higher molecular diversity may result in a lower microbial decomposition (Lehmann et al. 2020). Therefore, microbial diversity plays an important role in the decomposition of soil organic matter (SOM) (Domeignoz-Horta et al. 2021). However, little is known about how the intrinsic properties of SOM may affect microbial diversity. In this study, we investigate the interactions between the microbial diversity of soils with different land-covers and the composition and biogeochemical stability of organic substrates. Incubations were set up with three soils from three land-covers (grassland, old and young forests) to which organic substrates were added (sugars, nitrogen-containing aromatic compounds, cellulose, lignin-derived compounds, fatty-acids and cutine/suberine-derived compounds). Biological activity was followed by CO2 and O2 measurements during the incubation. Thermal stability and both bacterial and fungal community compositions were measured at the end of the incubations, respectively using the Rock-Eval® thermal method and both 16S and ITS sequencing.

Grassland soil microbial communities induced lower mineralization of nitrogen-containing aromatic compounds and higher mineralization of cellulose and cutin/suberin compounds, as compared to forest soils. The substrates composition mainly affected the abundance of bacterial communities from the forest soils, while the abundance of bacterial communities from grassland as well as the fungal communities behaved independently from the substrates. The soil microbial communities forest induced higher thermal stability of the cellulose, as compared to the soil microbial communities from grassland. Finally, our study evidences the strong implication of the microbial functional traits in the SOM stabilization and persistence.

References

Domeignoz-Horta LA, Shinfuku M, Junier P, Poirier S, Verrecchia E, Sebag D, DeAngelis KM (2021) Direct evidence for the role of microbial community composition in the formation of soil organic matter composition and persistence. ISME COMMUN. 1:64. https://doi.org/10.1038/s43705021-00071-7

Lehmann J, Hansel CM, Kaiser C, Kleber M, Maher K, Manzoni S, Nunan N, Reichstein M, Schimel JP, Torn MS, Wieder WR, Kögel-Knabner I (2020) Persistence of soil organic carbon caused by functional complexity. Nat. Geosci. 13:529–534. https://doi.org/10.1038/s41561-020-0612-3

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Soil C dynamics in (re)constructed soil profiles with added mineral material - a way of promoting C stabilization after moving soil?

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Only 3% of Norway’s total land is arable. Consequently, Norway is vulnerable to losses of agricultural land. Every year big infrastructure projects reduce agricultural areas by permanently taking land and leaving excavated soil in excess. To utilize excavated soil as a resource, avoid treating it as waste and to maintain its agricultural production potential, top soil could be moved and reconstructed in unproductive areas. At the same time, industries are accumulating excess material or byproducts, including different fractions of fresh mineral materials that may be suitable as soil additives when reconstructing agricultural soil profiles as so called Technosols. Fresh mineral materials may affect soil carbon sequestration by forming organo-mineral complexes promoting the stabilization of carbon in soils. Mineral associated organic matter (MAOM) is more persistent than particulate organic matter (POM), making this fraction important to lasting carbon stabilizing in soils.

The aim of the study is to examine the effects of four different mineral materials added to the B-layers of two different agricultural soils on carbon sequestration. For this purpose, an 8-month long soil column experiment was established, with reconstructed soil profiles, consisting of 5 cm deep A and 15 cm deep B layers. A layers were amended with 0.22 g 25% ^{13}C labelled ryegrass residues to study the fate of fresh organic C in columns with and without mineral additions. The columns were leached weekly, collecting DOC, DIC and major anions and cations. CO2 emissions are monitored periodically to support carbon mass balances. The mineralogical composition of mineral materials was evaluated by X-Ray Diffraction (XRD), and specific surface area of the particles was measured by the Brunauer−Emmett−Teller (BET) method by nitrogen adsorption. At the end of the experiment, the soil will be fractionated into POM and MOAM.

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Soil stabilization of biochar amendments using natural and synthetic colloidal clay-stabilized mineral additives.

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Biochar is a carbon-rich material produced by pyrolysis of organic waste and is used as an amendment to increase soil fertility. Biochar produced at low pyrolysis temperatures tends to have a lower half-life than biochar produced at higher temperatures. In this study, we investigated the use of different clay co-amendments to increase the stability of date palm leaf biochar pyrolyzed at 450 °C. Biochar decomposition was measured by microbial respiration (cumulative CO2 production) and compared with microbial enumeration and 16S rRNA diversity. Local 2:1 clays extracted from a dam sediment sample were tested as sustainable alternatives to the synthetic Allophane and Ferrihydrite clays. Homogenous biochar clay mixtures were prepared in stirred suspensions at different concentrations (0, 0.032, 0.064, 0.128, 0.256, and 0.512 % by mass), dried, and applied to the soil at 2.5% by weight. The results showed that the addition of different clays to biochar resulted in a stabilization effect, bringing respiration rates closer to those of unamended soils. Ferrihydrite was the most effective treatment at the maximum dosage tested. The 16S rRNA prokaryotic community taxonomic diversity characterization showed higher diversity in control soils than in soils treated with biochar and clays and revealed a decreased abundance of archaea in samples amended with biochar and clays. Additionally, the clay coating of biochar reduces its prevents its undesirable soil alkalinization of arid-land soils. These findings highlight the potential of biochar and clay as effective soil management strategies to enhance biochar stability.

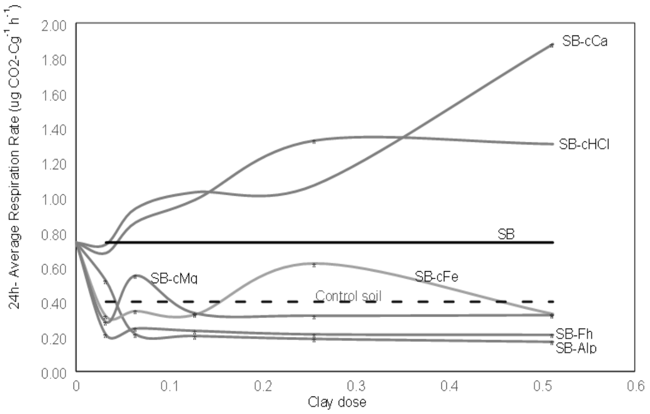

Fig. 1. Average respiration rate (µg CO_2-C g^{-1} h^{-1}) after one-day incubation with 2.5% biochar containing (0.032, 0.064, 0.128,0.256 and 0.512)% clays of different types (SB= soil biochar; SB-Alp= soil biochar with allophane; SB-Fh= soil biochar with ferrihydrite; SB-cFe= soil biochar coated with iron; SB-cMg= soil biochar coated with magnesium; SB-cCa= soil biochar coated with calcium; SBcHCl= soil biochar with hydrochloric acid treated local clays).

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Beyond growth? The significance of non-growth anabolism for microbial carbon-use efficiency in the light of mineral-associated carbon stabilization

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The microbial origin of stabilised soil organic C has received increasing attention. Findings suggest that microbial-derived C may make up a quarter to more than half of total soil C with the majority stabilised in mineral-organic associations. The microbial metabolic performance is a key factor in soil C dynamics, because microbes determine the fate of C during decomposition. They partition C between anabolic biosynthesis of various new microbial metabolites and catabolic C emissions (i.e. respiration). This partitioning is commonly referred to as microbial carbon-use efficiency (CUE). The reuse of C during biosynthesis provides a potential for the accumulation of microbial metabolic residues on mineral surfaces.

Current concepts of microbial CUE neglect microbial non-growth metabolites which can make up considerable parts of the microbially processed C. Commonly, CUE is quantified from C incorporated into biomass or used for growth and C released as CO_2. Extracellular metabolites, such as polymeric substances (EPS), exoenzymes or nutrient mobilizing compounds, as well as intracellular maintenance metabolites, such as storage compounds or endoenzymes, are ignored although they experience similar affinities to mineral surfaces as growth residues.

Based on theoretical considerations and two case studies, we highlight that disregarding non-growth anabolism can lead to severe underestimations of CUE and thus the potential for microbial-derived C stabilization in mineral-organic associations. The two case studies demonstrate that neglecting exoenzyme and EPS production can underestimate CUE by more than 100% and up to 30%, respectively. Our findings and considerations challenge the current ways how CUE is measured. We will therefore (i) scrutinise the idea that non-growth anabolism can be ignored for CUE investigations, (ii) suggest adjustments to common CUE approaches, (iii) demonstrate that current assessments of CUE measure only an ‘apparent’ CUE which could significantly underestimate ‘actual’ CUE, (iv) outline research needs and potential ways forward.

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Soil aggregate and water response to rain in different agricultural management systems

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Aggregate stability is a valuable field metric of soil "health" because it integrates physical and biological functions. However, soil aggregation is inherently vulnerable to changes with rain, due to both physical dissolution of binding agents and fluctuations in microbial activity across the soil pore matrix. Exploring the soil response to rain can both inform practical questions, such as vulnerability to compaction during wet times of year, and help inform our mechanistic understanding of aggregate breakdown and re-formation. We investigated the effect of different agricultural management practices (tillage, crop rotation, cover crops) on volumetric soil water content and soil aggregate response to rainfall on Mollisols and Alfisols in Southern Minnesota, USA. From April through October 2021 and 2022, we collected data from five tillage and cover crop treatments in replicated plots at the Southern Research and Outreach Center in Waseca, MN, and at six paired, on-farm sites representing "conventional" (full-width tillage, primarily corn-soybean rotation) and "soil health" (reduced tillage, cover crop) systems. We monitored volumetric soil water content and soil aggregate distributions (wet-sieving) within 24 hours before and after rainfall events >1.25 cm. Few differences in water capture, as measured by an increase in volumetric water content after rain, were observed across all locations. However, management treatment altered aggregate distribution response to rainfall on farms only. Generally, soil health farm fields increased the proportion of >2mm aggregates after a rain, while conventional sites lost these macroaggregates and gained aggregates <1mm. The initial conditions (pre-rain volumetric water content, pre-rain proportion of >2mm aggregates) were also important in the model, but after controlling for those factors, the data showed that aggregation processes in the soil health system were fundamentally different. Instead of slaking and dissolution of binding agents at wetting, aggregate-building processes such as hyphal growth and microbial activity may be more prevalent in these systems. More research is needed to illuminate which processes are involved, and how management can encourage these soil functions.

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Sustainability in agricultural practices: a comparative analysis of soil quality and yield in organic versus conventional pomelo orchards in Tainan, Taiwan

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Abstract：To meet the global 2050 net-zero emission goal, Taiwan's Ministry of Agriculture has set a target for net-zero emissions in the agriculture sector by 2040, identifying organic farming as a key strategic approach. This study investigates the environmental impacts and productivity differences between organic (OF) and conventional farming (CF) in ‘Madou Wendan’ pomelo orchards in Tainan, Taiwan. It aims to assess the feasibility and potential net-zero benefits of transitioning to organic practices in the orchards. Over a two-year period (2022-2024), research was conducted at eight trial sites, analyzing seasonal variations in soil organic matter (SOM), microbial populations, soil aggregate stability, and enzyme activity, as well as pomelo yields. Results indicated that SOM, microbial populations, and aggregate stability did not differ significantly between OF and CF across various seasons ($p > 0.05$). However, soil enzyme activity in OF consistently demonstrated higher than in CF, although these differences were not statistically significant ($p > 0.05$). CF produced higher yields in 2022, but by 2023, productivity between OF and CF equalized. These findings underscore that organic farming can achieve yields comparable to conventional methods while potentially enhancing certain soil biochemical properties. This study supports the feasibility of transitioning to organic farming as a sustainable agricultural practice that can contribute to Taiwan’s net-zero strategies.

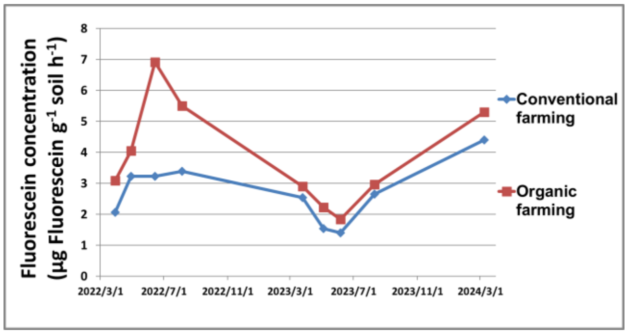

Fig.1 Comparison of microbial enzyme activity in conventional and organic pomelo orchards.

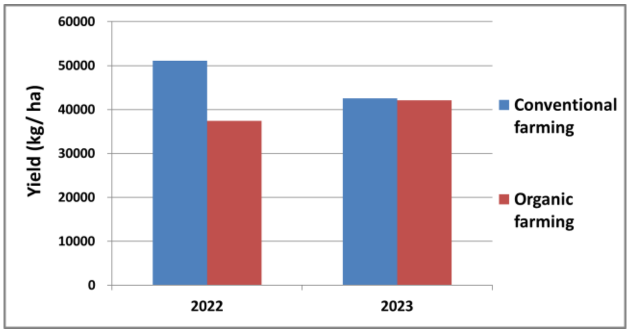

Fig.2 Pomelo yield comparison between conventional farming and organic farming for 2022 and 2023.

Kaolinite and Montmorillonite Inhibit the Decomposition of Plant Residues but its Effect Diminishes at Higher Temperature and Humidity

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Clay minerals in soils are key factors that regulate the decomposition of plant residues and soil organic matter. Simultaneously, changes in environmental conditions such as temperature and humidity are significant aspects of global climate change. Understanding how these factors affect the decomposition of plant residues is crucial for assessing the soil carbon (C) cycle and its feedback mechanisms. Although it is known that increases in ambient temperature and humidity generally promote the decomposition of plant residues, the specific role of clay minerals on this process remains less understood. In our study, we compared the changes in the decomposition of plant residues (*Artemisia argyi L.*) under different temperatures and humidity levels in constructed model soils comprising 100% quartz sand (Q-soil), 20% kaolinite + 80% quartz sand (K-soil), and 20% montmorillonite + 80% quartz sand (M-soil). After 12 months of incubation, the plant residues in Q-soil exhibited the lowest C remaining, indicating the fastest decomposition. Compared to Q-soil, the amount of C remaining increased by 4-11% and 8-23% in the K-soil and M-soil, respectively, suggesting that both kaolinite and montmorillonite inhibited the decomposition of plant residues, with montmorillonite showing a stronger inhibitory effect. This inhibition may occur through mineral association by adsorption, increasing the stability of plant residues and their metabolites against the microbial decomposition. Furthermore, this inhibitory effect was diminished at higher temperature and humidity. The amounts of C remaining in M-soil decreased by 5% and 1% at higher temperature and humidity, respectively. This suggests that temperature is a more critical factor than moisture in decomposing plant residues and soil organic matter, particularly in clay-rich soils. Additionally, Q_{10} (temperature sensitivity) was significantly higher in M-soil than in other soils ($P < 0.05$), indicating that complexation of organic matter with montmorillonite gives tolerance against microbial decomposition but its effect diminishes at higher temperatures. This could be due to the dissociation and microbial decomposition of montmorillonite-organic matter complexes at elevated temperatures. The present study clarified that changes in temperature would accelerate the decomposition of mineral-organic matter complexes, and this trend is more obvious when the interaction between the organic matters and clay minerals is stronger. This study underscores the significant role of clay minerals in modulating organic matter decomposition and indicates that the effects of warming on soil C cycling may be more complex than previously understood.

Weakening of Fe-Bound Organic Carbon Preservation Due to Hypoxia Induced by Coastal Algal Blooms

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Estuarine regions are hotspots for carbon burial in marine environments, where reactive Fe-bound organic carbon (OC-Fe$_{(R)}$) plays a crucial role. Due to climate change and human activities, algal blooms have expanded in coastal areas, potentially inducing hypoxia that could affect the stability of OC-Fe$_{(R)}$ in sediments. Research on the effects of algal blooms on coastal OC burial is limited and mechanistically unclear. To address this gap, we collected sediment and bottom water samples from the north of Changjiang estuary (an Ulva bloom area) and simulated the algal bloom deposition by adding different amounts of algal biomass to the sediment. During the incubation, we monitored the CO_2 flux and collected samples of overlying water and sediment samples for organic carbon and nitrogen analyses at predetermined intervals: days 1, 2, 5, 10, 15, 30, 45, 60, and 110.

The results showed a general decrease in the total organic carbon in both the overlying water and sediments throughout the incubation. For the overlying water, the dissolved organic carbon (DOC) exhibited high dynamics at the beginning of the incubation, likely due to the balance between microbial activity and DOC release. Notably, the periods of high DOC variability corresponded with times of high CO_2 flux. In the sediments, the total organic carbon (TOC) and nitrogen (TN) levels changed more slowly than in the overlying water. Additionally, the TOC and TN of the sediments in the algae-added group decreased to the initial values of the sediments at the end of the incubation. Using the selective dissolution method, we found that the content of low-crystallinity Fe bound OC (3.68-10.58 mg/g) was highest compared to that in organometallic complexes (0.11-0.26 mg/g) and high-crystallinity bound OC (0.25-0.27 mg/g) in the algal-added group in the whole process. Moreover, by the end of the incubation period, the content of organometallic complexes was greater in the algae-added group than in the untreated group, suggesting that the added algae might be partially incorporated into these complexes. Furthermore, the content of low-crystallinity Fe bound OC decreased continuously, which might be attributed to the hypoxia conditions induced by the algal bloom and was a result of the release of organic matter following the reduction of reactive metals. The high-crystallinity Fe bound OC was not significantly affected.

These findings suggest that the deposition of algal blooms may impact the stability of OC-Fe$_{(R)}$ by altering the redox conditions in sediments, consequently influencing the preservation of organic carbon burial in coastal areas. This study enhances our understanding of the effects of algal blooms and deepens our insights into the dynamics of coastal carbon preservation.

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Biomarker analysis of distinctive deposits formed in the inland mountain areas in Japan during glacial periods

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Paleosols are the soils formed on land in the past. Soil profile reflects source materials, microtopography, and climatic and environmental conditions. Although most charactersistics of paleosols have been declined due to erosion and diagenesis, the information for paleoclimatic and paleoenvironmental reconstructions has been recorded in the paleosols. Recently, organic geochemical proxies such as biomarkers, which are molecular fossils derived from specific organisms, have been applied to the paleosol study. In the present study, we performed biomarker analyses of the paleosols from Lake Suwa (Nagano Prefecture) and slope deposits from the Hidaka Mountains (Hokkaido) and compared these deposits to obtain the understandings for characteristics and behavoirs of organic matter in the paleosols.

We used a sediment core (ST2020) collected from the shore of Lake Suwa and a slope deposit core (NS-BR-01) from Hidaka mountains. The ST2020 core contains some paleosol layers in lacustrine sediments, indicating changes of lake water level (Hatano et al., 2023). The ages of ST2020 were determined by AMS ^{14}C dating, and the lowermost horizon was estimated to be about 27ka. Sedimentary facies indicated that the depositional environments varied from meandering fluvial, lacustrine, and delta in the ST2020 core (Hatano et al., 2023). We also picked up some sediments with plant roots. In Hidaka Mountains, central Hokkaido, there are slope deposits formed by periglacial processes. The NS-BR-01 core was mainly composed of poorly sorted silts and sands with the tephra layer (Ta-d (9ka)) above periglacial deposits (Koyasu et al., 2022). The uppermost part was andosols. The sediments were extracted by solvents and then separated into fractions by silicagel column. The apolar and polar fractions were analyzed by GC-MS.

In both sediments, *n*-alkanes, *anteiso*-alkanes, and C_{30} hopanes were identified. We analyzed carbon preference index (CPI) of the long-chain alkanes and ββ-hopane ratios as the diagenetic and source proxies. The paleosols and plant root-contained sediments from ST2020 exhibited lower CPI values and higher ββ-hopane ratios. *n*-Alkane compositions in roots are reported to be less predominances of odd carbon numbers as previous studies (Gocke et al., 2013). Also, the biosynthesized ββ-hopanes were abundantly supplied to the paleosols as a result of higher microbial activity in rhizosphere (Belin et al., 2018). These results implied the higher contribution of organic matter derived from roots and microbes in rhizosphere. Moreover, higher concentrations of *anteiso*-alkanes, which was considered to be microbial origin (Matsumoto et al., 1992), in these samples were concordant with the ββ-hopane results. In NS-BR-01, the CPI values were higher in all samples, and the ββ-hopane ratios were lower. The ββ-hopane ratios correlated positively with the concentration of *anteiso*-alkanes ($R^2>0.58$). The higher ββ-hopane ratios in the upper part of the NS-BR-01 might reflect better preservation and/or higher microbial activity caused by warmer and more humid climate in the deglacial stage.

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Age dating soil organomineral complexation from both sides: a comparison of $\Delta^{14}C$ and fallout radionuclide (FRN) chronometers

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Associations between organic and mineral matter is fundamental to the stabilization and storage of soil carbon. Accurate rates of organomineral complex formation and export from surface to deep soils is critical for predicting and monitoring soil carbon storage in a context of modern environmental change. Age dating the organic side of the organomineral complex is possible using bomb-pulse $\Delta^{14}C$, but the ^{14}C system in soils is complicated by open-system reservoir effects including uncertain lag times between carbon assimilation and input to soils, below-ground production of root biomass, and microbial decomposition. As a new alternative dating system, here we describe recent advances in fallout radionuclide and short-lived radionuclide chronometers that date the minerals of organomineral complexes. We use a linked radionuclide accumulation model (LRC) based on two radionuclides, ^{210}Pb and ^{7}Be. Just as radiocarbon is taken up while leaves are alive, interactions between these radionuclide metals and organic matter begin in the foliage. Direct comparison of $\Delta^{14}C$ with our LRC in temperate forest litter and organic soil horizons shows a strong linear correlation [$R^2=0.91$, $n=28$], but with ^{14}C ages offset by up to 20 years for individual soils and averaging 4.4 years across the dataset [4.4 ±4.8 SD, $n=28$]. Further, long-term tree leaf timeseries measurements at one site reveal that carbon ages based on the NH1 atmospheric curve underestimate the known age of local foliage by an average of 3.1 years [±0.5 SE, $n=8$], a bias we attribute to local fossil fuel combustion. Comparing age estimates across organic soil horizons, ^{14}C ages are older than LRC ages towards the surface but converge at depth. Centennial carbon accumulation rates calculated from our LRC dates match predictions from ecosystem carbon cycle models at three temperate forests in the northeastern United States. Future work will focus on deeper mineral horizons to investigate if ages of organometallic colloids continue to track the ages of bulk soil carbon at depth. The comparison between these two chronometers is yielding new insights into soil organic matter cycling and the importance of organo-mineral interactions.

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Chemical stabilization of vanadium by forming biochar-vanadium-nano oxide complexes

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Vanadium (V) is a re-emerging potentially toxic element of multiple valencies, and it has the potential to transform into a mobile and toxic V^{5+} form depending on the soil's organic matter content, redox status, and pH. The objective of this study was to investigate the V stabilization potential of biochar alone (BC) and BC combined with nano oxides of iron (Fe-O), aluminum (Al-O), and titanium (Ti-O) in an alkaline soil. An uncontaminated soil was collected and artificially contaminated by mixing with sodium orthovanadate at the rate of 200 mg kg^{-1} of V. A five-month incubation study was conducted at two temperatures (2 months at 4 ˚C followed by 3 months at 22 ˚C) with contaminated soil unamended or amended with BC, BC+Fe-O, BC+Al-O, and BC+Ti-O (BC at 5% and oxides 1% w/w) in triplicates. Soil moisture was maintained at the field capacity by adding water weekly. Pore water was collected periodically and concentrations of V, Fe, Al, and Ti in pore water were analyzed using atomic spectroscopy. At the end of the incubation period soils were air-dried and were subjected to operational speciation of V using the BCR sequential extraction procedure. Surface characteristics of the V+BC+nano oxide complexes were examined by scanning electron microscopy- energy dispersive spectrometer (SEM-EDS), Fourier transform infrared spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS). During the incubation period, pore water V concentrations exhibited variability across all treatments, ranging from 2 to 7 mg L^{-1}. The lowest V concentrations were observed at cold temperatures (4˚C). Significantly lower V concentrations were reported in all amended treatments compared to the unamended control. However, pore water concentrations of Al, Ti, or Fe among the treatments did not show any significant differences indicating minimum environmental consequences due to the addition of nano oxides at a 1% rate. At the end of the incubation period, amended treatments (BC, BC+Fe, BC+Al, and BC+Ti) showed reductions in pore water V concentrations by 27%, 31%, 36%, and 40%, respectively, compared to the control treatment. This suggests that the combination of biochar with metal oxides forms stable BC-vanadium-metal oxide complexes, contributing to the stabilization of V in soil.

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Study of Deep Learning-Based Image Segmentation of Soil X-Ray CT Images and 3D Structure Analysis

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For non-destructive analysis of the soil, X-ray computed tomography (XCT) has been used to acquire 3D images of the samples. To quantify the ratio and distribution of the components in the images, accurate image segmentation method is required. However, conventional image processing methods based on intensities of the data cannot separate them automatically and includes mis-classified regions.

Recently, several deep learning-based methods have been proposed to overcome the issue, especially for separating pores and solid phases.

In this study, we applied several deep learning-based methods using convolutional neural network (CNN) to discriminate several phases of the actual XCT images of soils and compared those results to that of a conventional method. Additionally, we quantified the volume fractions of the components, the connectivity of pore networks, and the permeability of the samples.

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Effect of European beech (*Fagus sylvatica* L.) and small-leaved lime (*Tilia cordata* Mill.) admixtures in European larch (*Larix decidua* Mill.) stands on the decomposition of larch needles

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Studies on the decomposition of European larch (*Larix decidua* Mill.) needles and the associated changes in their chemistry were carried out in a pure larch and mixed stands (Table 1) in central Poland, representing a cold climatic zone with warm summers and a humid continental climate. The investigated stands were located in the same complex of Planosols developed from the Late Pleistocene silty sediments of aeolian origin overlying fluvioglacial and glacial deposits. The soils were strongly acidic and relatively rich in total organic carbon (TOC) and nutrients.

Table 1. Basic characteristics of the studied stands

Stand code	Contribution of tree species (%)			Stand density (trees per ha)	Larch age years
	European larch	European beech	Small-leaved lime		
L	100.0	0.0	0.0	647	30
LB	14.6	85.4	0.0	1413	70
LBL	25.0	44.9	30.1	1040	70

The litterbag method was used in this study. Initial material was collected from pure larch stand in autumn 2019, air-dried, thoroughly mixed, placed in bags (15 grams dry mass per bag), and exposed in 3 replicates per stand. Samples of decaying needles were collected every 3 months over a period of 2 years, dried at 65°C, weighed, milled into powder, and analysed using standard procedures. Analyses included content of lignin, total phenolic compounds, TOC, and nutrients (N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn). The decomposition rate (k) was calculated based on mass loss. The data obtained were statistically analysed to identify differences between stands and temporal trends.

The initial material contained 458.9 g kg^{-1} of lignin, 6984.1 mg kg^{-1} of phenols, 6198.5 mg kg^{-1} N, 313.9 mg kg^{-1} P, 1550.7 mg kg^{-1} K, 10497.5 mg kg^{-1} Ca, 1967.6 mg kg^{-1} Mg, 656.0 mg kg^{-1} S, 158.8 mg kg^{-1} Fe, 4365.9 mg kg^{-1} Mn, 2.4 mg kg^{-1} Cu, and 33.3 mg kg^{-1} Zn. The TOC:N ratio was 69:1, indicating nitrogen deficiency. The decomposition rates (k) were not statistically different between the stands (0.66±0.13 – 0.74±0.13). The decomposition of larch needles was accompanied by changes in their chemistry. Relatively slow changes were typical for lignin and TOC, while much more dynamic changes were observed for phenols and nutrients. Most of the elements showed typical for them dynamics, such as increasing N content due to microbial colonisation. In general, the trends observed showed low variability depending on the stand. This may indicate the minor role of beech and lime admixtures in larch stands on fertile soils as a factor influencing the decomposition of larch needles.

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Changes in organic and inorganic components of soil during vegetation recovery process after the eruption on Miyake-jima island in 2000

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On Miyake-jima island. a large amount of volcanic ash was emitted during the eruption in 2000, devastating the vegetation on the mountainside. Currently, the vegetation has been recovering to the extent that species like *Miscanthus condensatus* and *Alnus sieboldiana* cover the entire mountainside. Previous studies have reported the formation of surface A horizon along with soil genesis and stratification progressing with the revegetation. In this study, soil survey was conducted at multiple sites in different stages of vegetation transition to understand the changes in organic and inorganic components of the soil in the recovery process more than 20 years after the eruption, and general physicochemical analyses of the soil were examined.

The total carbon and nitrogen content of the A horizon at the IG9 site, which is advancing in woody plant growth and forestation, showed values equivalent to the surface soil of the CL site where soil formation had progressed, indicating the accumulation of organic matter in the surface soil. However, comparing the values of aluminum content extracted by selective dissolution methods such as pyrophosphate and melanic index, it was suggested that the carbon content at forestation sites mainly originated from fresh organic matter. On the other hand, considering that the values of $\mathrm{Al_p/Al_o}$ exceeded 0.5 at forestation sites and *M. condensatus* grassland, the formation of Al-humus complexes and steady soil formation were suggested to be progressing. Comparing with the characteristics of buried surface layers, it was considered possible to position Miyake-jima volcanic ash soils in the process of forming allophane-rich Andosols, reflecting differences in vegetation due to elevation and progressing the formation of humus complexes due to increased organic matter supply along with vegetation recovery.

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Tree species traits and their microbiome interact with soil properties to shape soil organic matter composition

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Soil organic matter (SOM) is a major reservoir of carbon in forest soils. But information on tree species impact on the form in which SOM accumulates and how this varies with soil properties is lacking and hampers the implementation of forest management practices aimed at optimizing carbon sequestration in soil.

To determine the impact of tree functional traits on SOM quality, a series of topsoil samples were collected from five European common gardens. The trees exhibiting different N-fixing abilities (N-fixing versus non-N-fixing), mycorrhizal associations (arbuscular (AM) versus ectomycorrhizal (ECM)), and types (broadleaf versus conifer). The sites were distributed over a gradient in soil properties, ranging from coarse soils to finely textured soils and varying in their amount of poorly crystalline oxides and exchangeable base cations. They were either previously utilized for agricultural purposes or had previously been forested. The molecular fingerprint of SOM and proxies of plant-derived and microbial-derived SOM were obtained using pyrolysis coupled to gas chromatography–mass spectrometry (Py-GC/MS).

An analysis of variance indicates that 24% of the variance in biochemistry is explained by tree species, while 30% is linked to soil properties (clay + silt, Ca + Mg exchangeable and Fe + Al tamm). The results indicated that plant remains, and microbial-derived organic nitrogen are more prevalent in soil types that are characterized by the presence of fine particles and exchangeable base cations.

In contrast, sandy soil depleted in exchangeable cations was characterized by the presence of abundant aliphatic and a notable reduction in plant residues. The influence of tree species on SOM appears to be more pronounced in soils with a coarse texture than in those with a fine texture or enriched in base cations.

The N-fixing ability resulted in an increase in N-compounds and a more pronounced microbial signature in N-compounds and polysaccharides. The AM-association was found to enrich the SOM in N-compounds, with most of these compounds being derived from a microbial source, in contrast to the ECM-association. This finding challenges the prevailing view that AM litter is degraded more rapidly than ECM-associated litter. In fact, the SOM contained a greater proportion of lignocellulosic residues than the ECM-associated trees. In the temperate common garden of the study, planted with conifer plots, we observed a depletion in lignin compared to broadleaf plots. This depletion is attributed to a more efficient lignolytic activity of saprotrophic fungi. This study demonstrates that the interactions between mineral soil, microorganisms, soil organic matter and pedoclimate vary across Europe. Moreover, the results of this study suggest that further investigation into the potential of different tree species impact for long-term carbon sequestration would prove beneficial.

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Effects of long-term organic farming on soil organic carbon sequestration in Taiwan: A comparison between observations and the RothC and DNDC simulations

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Abstract

Soil organic carbon (SOC) is an important indicator of soil quality and health, as well as a significant carbon pool in the environment. Process-based soil carbon models were developed to simulate SOC changes in response to climate and agricultural practices, which provide an effective and accurate estimation for SOC turnover. In this study, RothC (Rothamsted Carbon) and DNDC (denitrification-decomposition) models were used to predict SOC dynamics in a southern Taiwan experimental field for the period from 1988 to 2024. There were two rotation systems: paddy-upland rotation (R1) and upland-upland rotation (R2); three farming managements, which were conventional farming (CF), intermediate farming (IF), and organic farming (OF), a total of six treatments at this experiment site. All the plant residues after harvest were incorporated into the soil. Based on the historical SOC data, the initial SOC was 1.36% in 1988, measured SOC after long-term farming under different managements turned into 1.49% in CF, 2.50% in IF, and 3.59% in OF in the R1 paddy-upland system, respectively. In the R2 upland-upland system, the observed SOC was 0.96% in CF, 1.15% in IF, and 1.96% in OF. The results indicated that long-term OF management significantly increased SOC, especially in the R1 system. However, observed SOC significantly decreased under the management of CF in the R2 system, and the DNDC model correctly simulated this change. The comparison between SOC observations and model simulations using root mean square error (RMSE) was necessary to evaluate the model's applicability and accuracy. DNDC simulations were more fitted to SOC observations, while RothC tended to overestimate SOC through all farming managements particulate in OF management. Since the RothC model was developed for non-waterlogged SOC simulations, the lack of an anaerobic respiration submodel and the constant decomposition rate, the model would not be suitable to apply on paddy fields, even relatively high-carbon inputs farming, as well as diverse organic matter application fields without model modification. Although using DNDC for predicting SOC was more suitable and powerful, daily and detailed input data are required to run the DNDC model, which has different degrees of impact on SOC and greenhouse gas simulations. As a result, further sensitivity and uncertainty analyses would help focus on predominant factors collection and facilitate the localized improvement of soil carbon models.

How far can clay minerals stabilize organic matter? A laboratory study

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Clay minerals are considered to protect organic matter (OM) from degradation by microorganisms and therefore to contribute to carbon sequestration in soils (Kleber et al. 2021). Recent studies showed contradictory results on the limit of mineral-associated organic carbon in agricultural soils (Georgiou et al., 2022; Begill et al., 2023; Cotrufo et al., 2023), suggesting that fine-scale processes are not yet well understood. This study aimed to determine the maximal capacity of different types of clay minerals to stabilize OM and evaluate the consequences on physical, chemical and microbiological properties. To this aim, we conducted a laboratory experiment using 3 types of clays differing in their specific exchange surfaces: kaolinite (30 m^2/g), montmorillonite (250 m^2/g) and sepiolite (600 m^2/g). Each microcosm (100 ml) consisted of the same 10 g ratio of sand (80%) and each type of clay (20%) mixed with different amounts (1, 5, 10, 25 or 50%) of green waste compost (GWC) in order to test the saturation of mineral surfaces. After 6 months of incubation, during which CO_2 emission was monitored weekly, we measured the water holding capacity, chemical parameters like pH and cation exchange capacity (CEC), and the microbial biomass by qPCR. The thermal stability of the OM was evaluated using Rock-Eval® analyses and biological stability by calculating the temperature sensitivity (Q_{10}) of the microbial respiration. Interactions between clay minerals and OM were also observed with the scanning electron microscope (SEM). As expected, mesocosms respiration measurements showed the lowest CO_2 release in sepiolite treatments, compared to montmorillonite, kaolinite and the control without clays. The large specific surface of sepiolite inevitably impacted microbial growth. The effect of clays on the OM mineralization was observed up to 5%, 10% and 25% of GWC in the mix, respectively with kaolinite, montmorillonite and sepiolite, suggesting that above these amounts of OM, mineral surfaces were saturated. SEM analyses revealed that without clay minerals, OM matter remained as particulates (POM), whereas in the treatments with kaolinite, montmorillonite and sepiolite addition the mineral-associated OM (MAOM) were visible. The microbial biomass, either bacteria or fungi, followed the amount of CO_2 released, suggesting that the accessibility of OM by microorganisms was limited by clay minerals, depending on their nature and saturation capacity. Rock-Eval pyrolysis revealed lower hydrogen and oxygen indices for the OM incubated with sepiolite and montmorillonite, indicating a higher thermal stability. The latter parameters were also correlated with biological stability as estimated by Q_{10} indices. Results showed the highest water retention in sepiolite treatments and with increased doses of compost, kaolinite and montmorillonite treatments remained on the same level. CEC and pH also varied significantly after the incubation, suggesting changes in physicochemical properties due to OM stabilization and interaction with clays.

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Carbon Distribution of the Brittleness Rice Straw Incorporation under the Alternate Wetting and Drying Practice

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Abstract

Straw incorporation has been considered an environmentally friendly practice to replenish soil carbon, nutrients, and improve soil health. The incorporation practice, however, is not well adopted by local farmers because straw residues cannot be decomposed completely during the short fallow period between two cropping seasons (i.e., < 30 days). The incomplete straw turnover likely interferes with the crop's growth on subsequent cropping, resulting from nutrient immobilization, harmful organic acid productions, and pest/disease outbreaks. Recently, the mutant brittle rice straw (BS) (*Oryza sativa L.* var. *IR64*) showed a great potential for the adoption of straw incorporation because of its fast-decomposed characteristics under the anaerobic (e.g., continuous flooding, CF) condition. The CF practice, on the other hand, likely led to substantial emissions of CH_4, one of the potent greenhouse gases (GHGs) with the global warming potential (GWP) of 28. Thus, the alternative wetting and drying (AWD) practice has been promoted to mitigate CH_4 emissions from paddy soils. So far, effects of the integrated BS addition and the AWD practices on the overall environment benefits have not been investigated. Thus, the objectives of this study were to evaluate the confounding effects of two straw incorporation (BS vs. wild-type) and two water regimes (CF vs. AWD) under two soil types (coarse- vs. fine-texture) on GHG emissions, dissolved carbon and nutrient leaching (i.e., DOC, DIC, and NO_3^-), aggregate stability, and the C dynamics among these phases using a microcosm incubation experiment. Results showed that the BS + AWD practice substantially reduce CH_4 emissions (9.3 ± 0.9 g m^{-2}) and the overall GWP (0.6 ± 0.0 kg m^{-2}) by approximately 91% and 81%, respectively, compared to the wild-type + CF practice (CH_4: 106.8 ± 0.9 g m^{-2}; GWP: (3.3 ± 0.1 kg m^{-2}) over the 150 days incubation ($P < 0.05$). Nevertheless, the faster straw turnover likely increased soil-leached nutrients, especially for the DIC (~10% increase) and NO_3^- (~ 50% increase). The BS return usually resulted in the higher C input than the wild-type straw in bulk soil. For soil aggregate formation, the straw return significantly improved soil aggregates with larger mean weight diameter (MWD) of 1.2 mm compared to the control (no straw addition) MWD of 1.0 mm but no differences were shown between the BS and wild-type straw incorporation. Therefore, this study showed that the integrated management of the BS return and the AWD practices has a great potential to improve the paddy agroecosystem by reducing GHG emissions and soil health.

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Contribution of minerals and organic material to the energetic signatures of soil – Insights from an artificial soil experiment and calorimetric analyses

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The thermodynamic perspective on soil systems is receiving increasing attention and has the potential to contribute to a holistic understanding of soil organic matter (SOM) dynamics. An integral part of new bioenergetic concepts is the energy content of SOM, but its determination particularly in mineral soils is challenging. A promising technique in this respect is thermogravimetry combined with differential scanning calorimetry (TG-DSC). Here, the heat flow and mass losses are measured simultaneously in a controlled combustion of the soil material during a temperature increase from 50 to 1000 °C under an oxidative atmosphere. Heat and mass changes in the range of 180-600°C are usually interpreted as the result from the exothermic combustion reaction of SOM and thus used to derive the energy content (combustion enthalpy, $\Delta_C H$) of SOM. Overlapping exo- and endothermic reactions by other non-oxidizing processes (e.g. dehydroxylation/-carboxylation and desorption of soil minerals) in that temperature range are often neglected because their quantification and differentiation from the rather strong exothermic oxidation reactions of SOM is challenging.

To disentangle these reactions, we determined the $\Delta_C H$ of cellulose as model substrate for SOM and additional soil minerals (quartz sand, quartz silt, goethite, illite, montmorillonite) 1) individually, 2) intensively mixed in the dry state, and 3) intensively mixed after several wetting-drying cycles. The minerals were mixed to create a silt loam texture and combined with cellulose to mimic a soil. Calorimetric analyses were conducted using a TG-DSC coupled with a mass spectrometer to analyze the gases (H_2O, CO_2) evolved during combustion.

First results show that the $\Delta_C H$ value obtained by TG-DSC is lower for cellulose to reference values obtained by combustion calorimetry as the standard method. Furthermore, $\Delta_C H$ differs when mineral compounds are mixed with cellulose, indicating that thermal reactions by mineral compounds affect the determination of the energy content by TG-DSC. This is supported by the analyses of the pure minerals, which revealed exothermic and/or endothermic side reactions for all minerals in the range from 180-600°C affecting the TG-DSC signal. Depending on the mineral composition of the soil, the energy content of SOM can be substantially over- or underestimated by TG-DSC. This is particularly important for soils rich in oxides and clay minerals.

In the next step we want to derive the thermal activation energy (E_a) from the thermograms, which represents the energy required to initiate the combustion of SOM. In other studies, the ratio of $\Delta_C H/E_a$ was conceptualized as the ’return on (energy) investment’ (ROI), a proxy to evaluate the microbial degradability of OM. Yet, the influence of thermal reactions by mineral soils on E_a remains largely unknown. Building on the findings of our artificial soil experiment, we aim to provide methodological considerations for the use of TG-DSC in the energetic characterization of SOM. This will take into account the contribution of mineral oxidation and the effect of organo-mineral associations on the energy content and E_a. This is crucial if energy fluxes and sinks in soil systems are to be quantified to better understand OM turnover and stabilization in soil.

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Organo-Mineral Interactions in Soils Across Tropical Volcanic Regions: Insights from EGA-MS Analysis

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Soil organic matter (SOM) regulates the C cycle of the terrestrial ecosystem, and the interactions between organic matter and soil minerals are crucial for SOM stability, particularly in tropical regions. Analytical thermal tools, such as evolved gas analysis-mass spectrometry (EGA-MS), offer robust methods for investigating these organo-mineral interactions with minimal side effects. By linking the biodecomposibility of SOM, thermal analytical tools can also evaluate the importance of organo-mineral interactions on the biochemical stability of SOM.

We investigated these interactions by examining soil samples from A- and B-horizons across four geoclimatic transects in volcanic regions of Tanzania and Indonesia, characterized by diverse pH (4.6–7.6), mineral composition (kaolin-dominant–active Al/Fe-dominant) and SOC contents (10–152 g kg^{-1}). These soils are classified as Ultisols, Alfisols, and Andisols. Using EGA-MS with continuous heating under a helium atmosphere, we explored the interaction between SOM and soil minerals. Kinetic model fitting on soil respiration curves was used to estimate the proportion of intermediate decomposable SOM pool, the major decomposable SOM source over decades.

Results showed that released organic matter (OM; 100–550°C) constituted 22–43% of SOC and 40–71% of total nitrogen, suggesting complete pyrolysis with the consideration of the inevitable carbonization process. A significant positive correlation was observed between the amount of released OM and the intermediate SOM pool, indicating its origin. EGA-MS spectra of multiple ion currents (19–500 m/z) revealed two primary peaks of OM releases: a thermal-desorption peak from 100–200°C and a broader pyrolysis peak between 200–550°C, subdivided into peaks centered around 280°C and 480°C. Similarly, two peaks centered at these temperatures were detected for spectra of 18 m/z (i.e., water), aligning with dehydroxylation temperatures of Al/Fe (hydr)oxides and kaolin minerals. More detailly, a continuous release of water between 200 °C and 400 °C was observed predominantly in soils rich in active Al/Fe (Al/Fe (hydr)oxides), matching the published thermogravimetry differential thermal analysis curves of allophane, imogolite, and ferrihydrite. Along with the minimal contributions to water release from organic matter (3.5 ±4.6%), EGA-MS spectra indicate the dominant role of hydroxyl-related organo-mineral interaction in regulating the thermal stability of SOM. The overlapping peaks of major OM release from decomposable SOM source (i.e., intermediate decomposable SOM pool) and dehydroxylation of Al/Fe (hydr)oxides and kaolin minerals highlight the significant impact of hydroxyl-related organo-mineral interactions on SOM stability on a decadal scale.

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Regulation of soil organic carbon, from plant input to microbial transformation and mineral interactions

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Plant derived organic matter (OM), entering soils either as aboveground plant litter or via belowground rhizodeposition or dead roots, undergoes microbial decomposition and transformation and finally ends up in various soil OM (SOM) pools. With two major solid SOM pools besides dissolved OM, namely particulate OM (POM) and mineral-associated OM (MAOM), the initially plant dominated OM is progressively transformed into microbial OM during decomposition. However, as mineral soils comprise highly heterogeneous systems over a wide range of spatial and temporal scales, the microbial transformation of plant OM and the formation of SOM is highly variable in time as well as in space. Processes controlling the persistence of SOM are especially determined at nm to µm scales at biological highly active biogeochemical interfaces. Thus, plant litter and roots form distinct soil hot spots fostering the interactions between microbiota, OM and mineral particles that are thought to control the long-term fate of soil carbon. The detritusphere and rhizosphere thus represent soil volumes that host the complex interplay of biological, chemical and physical soil processes that determine the fate of SOM. We will highlight the intricate connection between the transformation of plant derived OM via microbial processing and the formation of distinct SOM fractions and soil structures that regulate the persistence of organic carbon in soils.

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Building mineral-associated soil carbon with conservation agricultural management

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In the United States Coastal Plain, conservation agricultural management practices such as cover cropping and conservation tillage systems (e.g., strip tillage, minimal tillage, or no tillage) are implemented to promote soil carbon accumulation and improve soil health. These management practices have been shown to increase soil carbon storage, but the influence of agricultural management on accumulation of ecologically relevant fractions of soil carbon remains unclear. To address this gap, we measured total, particulate, and mineral-associated soil carbon pools at the end of a 7-year agricultural field trial to evaluate soil carbon response to different conservation management types. Four tillage systems – conventional, strip, minimal, and no tillage – and three winter cover rotations – fallow, winter cash crop, and high-biomass cover crop – were tested in a split plot design. Treatments that combined conservation tillage (i.e., strip, minimal, or no tillage) with a winter cover (i.e., cash crops and high-biomass cover crops) had greater increases in total soil carbon compared to conventional. Out of the four tillage systems, the strip tillage system accumulated significantly more surface and subsurface carbon. The findings thus far demonstrate that Coastal Plain agricultural soils have the potential to act as a carbon sink when using conservation agriculture practices. Size-based soil carbon pool fractionation (i.e., > or <53 µm) and characterization of soil carbon forms within each fraction using X-ray absorption spectroscopy will be performed to better understand pathways of soil carbon accumulation under conservation agricultural management.

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Soil organic carbon stabilization potential in mineral-associated organic matter is higher in red sandy soil than in black cotton soil in India

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Soil organic carbon (SOC) sequestration is essential for improving soil productivity and climate change mitigation, especially in the tropics. Mineral-associated organic matter (MAOM) in silt + clay fraction plays a vital role in SOC stabilization. Fine mineral particles, such as Al- and Fe- oxyhydroxide in acidic soils and Ca^{2+} in alkaline soils, generally contribute to the formation and stability of MAOM. The relative Al- and Fe- or Ca^{2+} contribution rate for SOC stabilization should be primarily controlled by soil pH. Ca^{2+} is known to have a lower SOC stabilization capacity than Al- and Fe- oxyhydroxide in MAOM, while the stabilization potential for newly added organic matter is still unknown. Thus, we aimed to compare the stabilization potential for various tropical soil types which have different soil pH in the tropics.

We collected surface layers (0–10 cm) of different soil types in India. Soils were classified as red sandy soil (Alfisols & Inceptisols, i.e., Al- and Fe- rich alkaline soils; n=5) and black cotton soil (Vertisols, i.e., Ca^{2+} rich alkaline soils; n=6). We incubated soils with 1.5 g C kg soil^{-1} of ^{13}C-labelled maize residue (leaf, C:N ratio=15.1, δ^{13}C=8.5 atom%) at 25℃ for 300 days. After the incubation, soils were physically fractionated into light fraction (LF: <1.7 g cm^{-3}), particulate organic matter (POM: 53–2000 μm), and MAOM (<53 μm). We measured the TC and δ^{13}C for each fraction and then calculated the ^{13}C residue-derived C in each fraction.

^{13}C residue-derived C in MAOM (MAOM-^{13}C) was significantly higher in black cotton soil (0.25–0.30 g C kg soil^{-1}) than in red sandy soil (0.20–0.28 g C kg soil^{-1}). In contrast, MAOM-^{13}C / mass of MAOM, which indicates the stabilization potential of MAOM, was significantly higher in red sandy soil (0.52–0.84 g C kg MAOM^{-1}) than in black cotton soil (0.33–0.56 g C kg MAOM^{-1}). This suggested that 1) in red sandy soil, Al- and Fe- associated MAOM should contribute to higher stabilization potential of MAOM fraction even in alkaline conditions, and that 2) in black cotton soil, SOC stabilizing potential of MAOM fraction should be low, due to the Ca^{2+}- associated MAOM, which should have lower stability than Al- and Fe- associated MAOM. In addition to these results, we will also add the analytical results of Oxisols in Cameroon (Al- and Fe- rich acidic soils; n=8) and discuss the impact of Al- and Fe- oxyhydroxide or Ca^{2+} rich conditions on soil SOC stabilization potential.

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The effect of soil management on the soil organic carbon fractions in tea orchards.

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Abstract

Proper soil management practices are essential for maintaining or increasing soil organic carbon content. Farmers applying mulch with pruned residues or peanut shells to the soil surface or implementing grass cover cropping contribute to the maintenance of soil organic matter, weed control, and soil moisture retention in tea orchards. Utilizing temperature-dependent differentiation aids in understanding the fractions of soil organic matter. The aim of this study was to investigate the soil (in)organic carbon fractions under different soil managements. This study conducts an investigation at the Taiwan agricultural long-term ecological research site located in Nantou. The soil analysis data was from 2021 to 2023. CA and CAII treatments involved the application of peanut shells and pruned branches. The SA treatment implemented grass-based cultivation in the field. Soil properties include soil pH, total carbon, total nitrogen, available calcium and magnesium, TOC400, ROC, and TIC900. Results revealed that soil organic matter was highest in the topsoil layer and decreased with increasing depth. Soil organic carbon levels were higher in the CA and CAII treatments, involving the application of peanut shells and pruned branches. In the 0-15 cm soil layer, the TOC400 of the CA and CAII treatments increased by approximately 61% compared to SA. In the 15-30 cm and 30-45 cm soil layers, the TOC400 of the CA and CAII treatments increased by approximately 18% and 26%, respectively, compared to SA. In the 0-15 cm soil layer, the ROC of SA increased by approximately 17% compared to CA and CAII treatments. In the 15-30 cm and 30-45 cm soil layers, the ROC of the CA and CAII treatments increased by approximately 14% and 27%, respectively, compared to SA. The ratio of TOC to ROC in the 0-15 cm soil layer was approximately 3.8-5.1 for CA and CAII, and approximately 2.0 for SA. The ratio of TOC to ROC in the 15-30 cm soil layer was approximately 2.4 regardless of treatment. The ratio of TOC to ROC in the 30-45 cm soil layer was approximately 2.3 regardless of treatment. The results indicate that mulching with peanut shells and pruned branches may contribute to the increase in soil TOC400 in topsoil. Additionally, they may supply more nutrients due to the easily decomposable TOC400. Further study will focus on the organic carbon forms and application rates of peanut shells and pruning residues.

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Changes in subsoil nitrogen pools and composition under management-driven deep soil warming

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In managed forests, intensive biomass removal has the potential to substantially alter the deep (e.g., to ~1-m depth) soil environment, with cascading impacts on carbon and nutrient cycling. At the Northwest Advance Renewables Project (NARA) Long-Term Soil Productivity (LTSP) site, biomass removal treatments have resulted in large (up to 5 °C) increases in summer soil temperature. In this work, we evaluated how these changes in the soil environment affected depth patterns in carbon age (via radiocarbon measurements), distribution of carbon across particulate and mineral-associated pools, abundance of reactive metals, and organic matter composition (via carbon and nitrogen X-ray absorption spectroscopy).

Sticky Soil Carbon –the stability of soil organominerals is controlled by OC carboxyl richness

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Reversing the trend of decreasing soil carbon stocks is important to help mitigate current environmental challenges. Improving knowledge on the mechanisms that control the stabilisation and persistence of soil organic carbon will provide a foundation to tackle the issue. This includes the mechanisms controlling the stability of organomineral associations, considered to be the most persistent pool of soil carbon. Uncertainties remain in how the composition of carbon involved in mineral associations can control the persistence of this soil organic carbon pool. Carboxylic acid richness of organic carbon (OC) are important indicators for OC stability in ocean sediments, however, it remains to be seen whether this is replicated for organominerals in terrestrial soil settings.

Experiments were set up to investigate if OC carboxyl richness controls the organomineral OC stability by using synthesised model organominerals. These model organominerals consist of simple homogenous carboxylic acids of varying carboxyl richnesses to more complex heterogeneous fungal and microbial necromass OC associated to ferrihydrite. Organomineral OC stability was tested by measuring the change in solid organomineral OC from before to after destabilisation treatments. These treatments were NaOH and NaOCl chemical washes that induce desorption and oxidation of OC, and redox fluctuations that enable the reductive dissolution of ferrihydrite. This accompanied a soil mesocosm incubation experiment containing ^{13}C labelled organominerals of varying carboxyl richness.

Results indicate that carboxyl rich OC associate more readily to ferrihydrite and have greater stability once in an organomineral, compared to carboxyl poor OC. Findings also show that heterogeneous necromass OC follows this trend, where carboxyl rich components of necromass are less vulnerable to destabilisation when associated to ferrihydrite, resulting in fungal necromass organominerals having the greatest OC stability compared to other microbial necromass organominerals. These results imply that carboxyl rich OC can enhance the persistence of the mineral associated pool of soil organic carbon.

Morphological and topological alterations of the pore space induced by mucilage amendment

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Soil structure, strength and arrangement are key factors concerning environmental maintenance due to their connection to soil erosion processes, surface and subsurface water flow and solute transport within the soil. Biopolymer secretion from plant roots and micro-organisms is known to affect these key characteristics, thereby differentiating the influenced soil from the bulk soil. Most research focus on aggregate strength and formation under bio-polymer amendment, or changes in flow associated with fluid property modifications. In this study, we focused on characterizing the alterations on the pore space itself morphologically and topologically and evaluate how these pore structure changes influence flow through the pore space.

We examined the effect of mucilage on the pore structure of a Loess soil under various conditions including air dried soil as a baseline; control (no mucilage); mucilage amended soil; control and mucilage amended soil undergoing wetting and drying cycles. Soil pore space images were obtained utilizing µCT imaging, whereas morphological and topological data was processed with a porous media specific Python library (PoreSpy). Simulation of water retention and flow was done by considering a simplified pore structure extracted from the image with OpenPNM, a Pore Network Modelling (PNM), Python framework.

Our current results of the pore space analysis, within the limitations of resolution, present a shrinking effect of the mucilage amended soils (~8% porosity reduction) where an additional wetting and drying cycles enhances shrinking (~1.5% porosity reduction). This reduction resulted from a greater shift to smaller pore sizes, although a minor increase was observed towards larger pores. Topologically, mucilage seemed to induce greater complexity of the pore space as was observed by a connectivity function and a tortuosity function which characterize the Euler-Characteristic and Geometric-Tortuosity as a function of the largest considered pore size within the connected pore space, respectively. Initial tortuosity for the mucilage treated soils was 1.5 times greater than the non-amended soils, while the wetting and drying cycles themselves did not seem to showcase any changes. Network modelling of an Invasion-Percolation Drainage scheme showed a greater trapping of the initial inhabiting wetting phase, which may be explained due to the greater complexity of the pore system. Our results demonstrate a significant shrinking effect of the pore space due to mucilage, particularly after drying. Further analysis is needed to fully understand the impact of these morphological and topological changes on flow and transport phenomena.

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Mechanistic control over chemical composition patterns of distinct soil organic matter fractions across various pedoclimatic conditions

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The storage and fate of soil organic carbon (SOC) is closely linked to the microbial decomposition and transformation of distinct pools of soil organic matter (SOM). Solid SOM pools can be separated by physical means, and thus it is possible to assess quantity, quality and/or turnover of distinct operationally defined SOM fractions. Whereas fractionation approaches that are based on pure size separation (e.g., <53 µm) that seek to quantify overall SOC storage in easy to obtain fractions, the use of combined density-size separation approaches offers an opportunity to assess distinct mechanisms that regulate SOC storage in more detail. With the differentiation into free and occluded particulate OM (POM) using a density separation and aggregate disruption, it is possible to differentiate into fresher mainly plant derived POM (fPOM), more decomposed POM in aggregated soil structures (oPOM), and mineral-associated OM (MAOM). We use a data set of POM and MAOM fractions derived from various pedoclimatic conditions spanning from polar to tropical ecosystems to assess possible general patterns in the distribution and chemical composition of these distinct soil fractions. We base the assessment of the quality of the fractions via C and N measurements as well as ^{13}C-CP/MAS nuclear magnetic resonance spectroscopic analyses.

We demonstrate distinct differences in the quality between POM and MAOM as well as fPOM and oPOM. The overall chemical composition of the MAOM assessed based on NMR spectra is rather determined by the specific mineralogy of the various soils. The composition of the POM fractions is clearly different with respect to particle size. Thus, small occluded POM, a fraction regularly ending up in any small size fractions with cut-offs of either <53 µm or <20 µm, clearly shows a high degree of decomposition with either high aromaticity or aliphaticity. This points to an important contribution of small POM to a rather persistent SOC pool in soils across the globe.

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Controlling factors for soil organic matter content in surface and subsurface horizons of non-volcanic soils

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This study investigated the effects of soil mineral components, climate, and geology on soil organic carbon (SOC) content. We used A and B horizon soils from 216 sites of non-volcanic soils in Thailand, Indonesia, Tanzania, Cameroon, and Japan. Soils were characterized for SOC content, standard physicochemical properties and soil mineral components that contribute to SOC content, such as clay + silt and acid ammonium oxalate extractable Al and Fe ($\mathrm{Al_o} + \mathrm{Fe_o}$). Parent material (geologic composition) was represented by total Al + Fe content. Correlation and regression analyses were applied to assess the contributions of soil mineral components to SOC content. Structural equation modelling was used to analyse effect paths and the relative contributions of soil mineralogical, climatic (e.g., mean annual temperature: MAT, excess precipitation: mean annual precipitation – potential evapotranspiration) and geological (i.e., total Fe + Al) factors. Correlation analysis suggested that $\mathrm{Al_o} + \mathrm{Fe_o}$ was the most important mineral component influencing SOC content in both A and B horizons. In B horizons, $\mathrm{Al_o} + \mathrm{Fe_o}$ was strongly correlated with SOC ($r = 0.79$–0.86), and the coefficient of $\mathrm{Al_o} + \mathrm{Fe_o}$ in the SOC regression was similar (3–5 mol C $\mathrm{mol^{-1}}$ $\mathrm{Al_o} + \mathrm{Fe_o}$) across soils with different degrees of weathering and pH ranges. Structural equation modelling explained 54% and 75% of the variance in SOC content for A and B horizons, respectively. In B horizons, SOC content was most strongly associated with $\mathrm{Al_o} + \mathrm{Fe_o}$ (0.76) and MAT (−0.59). $\mathrm{Al_o} + \mathrm{Fe_o}$ had a direct effect (direct effect: 0.76, indirect effect: not significant), whereas MAT had an indirect effect (direct effect: −0.15, indirect effect: −0.44), mainly via regulation of $\mathrm{Al_o} + \mathrm{Fe_o}$. In A horizons, SOC content was associated with MAT (−0.49), excess precipitation (0.28), and $\mathrm{Al_o} + \mathrm{Fe_o}$ (0.26), with MAT having a more direct effect on SOC (direct effect: −0.37, indirect effect: −0.12). We conclude that $\mathrm{Al_o} + \mathrm{Fe_o}$ in B horizons plays a key role in regulating SOC concentration through its strong stabilizing effect on SOC, and temperature indirectly affects SOC via its effect on $\mathrm{Al_o} + \mathrm{Fe_o}$ content. In contrast, A horizon SOC concentrations are strongly affected by climatic conditions that affect decomposition rates, with a secondary effect from $\mathrm{Al_o} + \mathrm{Fe_o}$.

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Modeling the measurement of organic carbon by using Vis-NIR for tropical soils

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Soil organic carbon (SOC) is an essential indicator for soil quality and health. Besides, the increase of SOC has been considered as a crucial resolution to mitigate the global warming. The content of SOC is conventionally analysed through destructive procedures, which are time-consuming and will produce a lot of chemical wastes. Therefore, it is necessary to develop an efficient measurement of SOC. Visible and near-infrared spectrometer (Vis-NIR) is a proximal sensor which can collect the reflectance spectra ranging from 350 to 2500 nm. The vibrations of functional groups in organic matter can be detected through Vis-NIR, and the reflectance can further be used to quantify the SOC content through the machine learning. On top of that, this approach offers a cost-effective and non-destructive method to measure SOC, which promotes the development of measurement, reporting, and verification (MRV) for carbon trade in the future. This study aimed to develop SOC prediction models based on Vis-NIR spectra and machine learning algorithm for four destructive SOC analyses including loss on ignition (LOI), Walkley-Black wet oxidation (WB), total organic carbon (TOC), and elemental analyzer (EA). For collecting the reflectance spectra, the NaturaSpec™ Portable Spectroradiometer (Spectral Evolution, Haverhill, MA, USA) was used. Soil samples with different parent materials and soil types in Soil Taxonomy from Taiwan were collected for this study. The data were randomly split into two subsets, including calibration set (75%) and testing set (25%). The prediction models were constructed using Cubist algorithm via R software. To choose the best parameters for the models, 10-fold cross validation was used. Four SOC models were built with different sample sizes: LOI (n = 144), WB (n = 554), TOC (n = 475), and EA (n = 82). Additionally, the coefficient of determination (R^2), root mean square error (RMSE), residual prediction deviation (RPD), and Lin's concordance correlation coefficient (LCCC) were used to evaluate the performance of models. The experimental results showed that the EA model was the best in the performance of prediction (R^2 = 0.81, RMSE = 2.87, RPD = 2.11, LCCC = 0.85), followed by the LOI model (R^2 = 0.65, RMSE = 6.33, RPD = 1.69, LCCC = 0.77). However, the WB (R^2 = 0.56, RMSE = 2.83, RPD = 1.18, LCCC = 0.72) and TOC (R^2 = 0.45, RMSE = 0.58, RPD = 1.32, LCCC = 0.57) models were poor in accuracy. In this study, the integration of Vis-NIR and machine learning offered a potential approach to estimate the SOC content in Taiwan. However, the performance of model will be better when the sample size and the range of SOC content become high in the future.

Effect of soil depths on plant residue decomposition using ^{13}C-labeled residues in Andosols, Japan.

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Understanding the soil organic carbon (SOC) cycle variability through the soil profile is crucial for managing SOC sequestration in deep soil horizons. The unique conditions of subsoil, including soil temperature, moisture, minerals, and microbial activity, compared to topsoil, influence the decomposition pattern of exogenous organic matter (e.g., plant residue), thereby affecting their accumulation and stabilization in soil. While the decomposition patterns of plant residue in topsoil have been extensively studied, the changes in decomposition with soil depth, particularly in *in-situ* conditions, are poorly understood. This study aimed to quantify the effects of soil depth and plant residue quality on *in-situ* residue decomposition patterns by using ^{13}C-labeled plant residues in Japan.

We conducted the *in-situ* incubation experiment in the experimental field of TUAT, Japan (Soil types: Andosols, mean annual temperature: 15.4℃, annual precipitation: 1599 mm). Soil samples from 10, 50, and 90 cm depth were collected and then mixed with ^{13}C-labelled maize residues of leaves (C/N = 21), stems (C/N = 31), and roots (C/N = 39) at a rate of 2.2 g C kg^{-1}. These were buried and incubated at the corresponding layer using PVC pipes (10 cm diameter × 2.5 cm height) with four replications (total of 192 pipes). We collected them after 3 months and plan to collect them after 6, 12, and 18 months.

From the three-month samples, we observed that the remaining rates of residue-derived C were 39-43% at 10 cm, 47-52% at 50 cm, and 49-61% at 90 cm depths. Notably, root and stem residues at 90 cm depth (Root: 61%, Stem: 49%) remained more substantial than at 10 cm (Root: 39%, Stem: 40%). On the other hand, the remaining rate of leaf residue did not significantly differ across the soil depths (43-51%). These findings indicate that the microbial potential to decompose the stem and root residue with relatively high C/N ratios was constrained in the subsoil, compared to the leaf residue with a low C/N ratio. At the conference, we will present the destination of the residue-derived C to light fractions(<1.7 g cm^{-3}), particulate organic matter (>53 μm), and mineral-associated organic matter (<53 μm). We will discuss the factors controlling the decomposition and accumulation patterns of residue-derived C across soil depths to identify the effective residue qualities for SOC sequestration in the subsoil.

Critical Evaluation of Low Carbon-Emitting Organic Resources on Net Ecosystem Carbon Balance and Soil Physicochemical Properties in Red Pepper Cropping System: 2-Year Field Study

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Low carbon (C)-emitting organic sources are widely considered promising solutions for enhancing C sequestration and improving soil quality in agricultural systems. Therefore, there is an urgent need for a thorough and systematic evaluation of organic resources to gain a comprehensive understanding of their actual impact on soil C dynamics. However, the impact has not been systematically assessed yet. This study aimed to evaluate the overall impact of low C-emitting organic resources on net ecosystem carbon balance (NECB) including C input and losses (CO_2 and CH_4) as output, crop productivity, and soil physicochemical properties in the red pepper cropping system. In red pepper cultivation fields, six treatments were installed: no fertilizer (NF), inorganic fertilizer (NPK), red pepper residue (NPK+R as R), compost (NPK+Com as Com), rice hull biochar (NPK+RB as RB), and wood biochar (NPK+WB as WB). These treatments were applied at rates of 0 and 5 Mg d.w ha^{-1} under the recommended fertilization level as N-P_2O_5-K_2O = 190-112-149 kg ha^{-1}, except for no fertilizer for two years in the field. For two years, WB was effective in significantly increasing C input, showing the highest value (5.56 Mg C ha^{-1}), and then followed by RB (5.70 Mg C ha^{-1}), R (3.90 Mg C ha^{-1}) and Com (2.73 Mg C ha^{-1}). Moreover, the C input through plants as net primary production (NPP) was highest at R (12.0 Mg C ha^{-1}) treatment, followed by RB (12.0 Mg C ha^{-1}), WB (11.5 Mg C ha^{-1}), Com (10.9 Mg C ha^{-1}). Overall C input was highest in WB treatment, suggesting a promising organic resource to potentially enhance soil C stock in soils. CO_2 emissions were highest at R (12.2 Mg C ha^{-1}) treatment, showing the highest C loss from the soil due to having more easily degradable C than other organic resources. CH_4 emissions were almost negligible among all treatments. Although NECB showed a negative value in all treatments, biochar treatments (RB and WB) significantly increased the value (-1.93 and -3.81 Mg C ha^{-1}, respectively) as compared to the NF (-9.59 Mg C ha^{-1}) and NPK (-8.63 Mg C ha^{-1}), irrespective of the years. This indicates that biochar could be a promising way to provide more C into the soils and to minimize its decompositions, enhancing soil C stocks. Overall fruit productivity significantly increased with organic matter applications. Particularly, R treatment was most effective in increasing cumulative fruit productivity as compared to NF and NPK, possibly due to releasing more nutrients into the soils than the other resources. Moreover, overall soil physicochemical properties including bulk density, pH, and total C etc. were also improved with the addition of organic resources, in particular biochars. In conclusion, the application of biochar such as RB and WB in red pepper cropping fields could be a reasonable soil management strategy to simultaneously improve NECB, crop productivity, and soil properties in agricultural ecosystems.

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Responses of soil organic carbon to precipitation change in grassland ecosystems

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Frequent global extreme drought and precipitation events have profound impacts on soil organic carbon (SOC) pool in grassland ecosystems. Soil microorganisms are considered important drivers in the accumulation of SOC through the *in vivo* turnover and *ex vivo* modification pathways. Thus, the response of SOC to precipitation change is largely regulated by soil microorganisms. However, it remains unclear how precipitation change affects SOC by influencing soil microbial *in vivo* turnover and *ex vivo* modification pathways in grassland ecosystems.

Our study was carried out based on the China Global Change Network Control Experiment, using the identical field precipitation experimental design. The precipitation manipulation experiments, including increased 50% precipitation, decreased 50% precipitation, and Control, were begun in 2018. We collected 0-10 cm soil samples from nine grassland ecosystems (Fig.1) in 2020, including alpine steppe, alpine meadow, temperate desert steppe, temperate typical steppe, and temperate meadow steppe. We investigated the effects of three years of precipitation change on SOC content, microbial residue carbon content, and soil extracellular enzyme activity in the large-scale grassland ecosystem, analysing the effects of the *in vivo* turnover and *ex vivo* modification pathways on SOC accumulation in precipitation change.

Our results showed that precipitation treatment had a limited effect on SOC content (p=0.13), compared with control plots. However, compared with control plots, both increased and decreased precipitation treatment increased soil microbial biomass (12.4%~24.6%, p<0.001), decreased soil extracellular enzyme activity (-2.2%~-23.7%, p<0.001), and decreased microbial residues (-16.1%~-29.1%, p<0.001). The results of partial least squares path modelling showed that the response of soil properties to precipitation change was the crucial factor driving the response of microbial residues (Standardized path coefficient=0.51, p<0.01) and soil extracellular enzyme activity (Standardized path coefficient=0.56, p<0.001). Subsequently, both microbial residues (Standardized path coefficient=0.47, p<0.001) and soil enzyme activity (Standardized path coefficient=0.43, p<0.001) had consistent and significant positive effects on SOC content. Our results indicated that altered precipitation did not affect SOC content, mainly due to the consistent effects of precipitation change on microbial residues and soil extracellular enzyme activity. Altered precipitation decreased soil microbial residues content, limiting the pathway that dead soil microorganisms contribute to SOC formation via the entombing effect. And altered precipitation decreased soil extracellular enzyme activity, reducing the ability of soil microorganisms to ingest and utilize soil substrate carbon, ultimately decreasing the decomposition of SOC. The consistent inhibitory effect of precipitation change on the *in vivo* turnover and *ex vivo* modification pathways jointly resulted in no significant changes in SOC accumulation.

Our study revealed that the trade-off between soil microbial residues and soil extracellular enzyme activity led to no significant changes in SOC content. The study enhances our understanding that the role of the *in vivo* turnover and *ex vivo* modification pathways in regulating SOC accumulation at the large-scale grassland ecosystem under global extreme drought and precipitation.

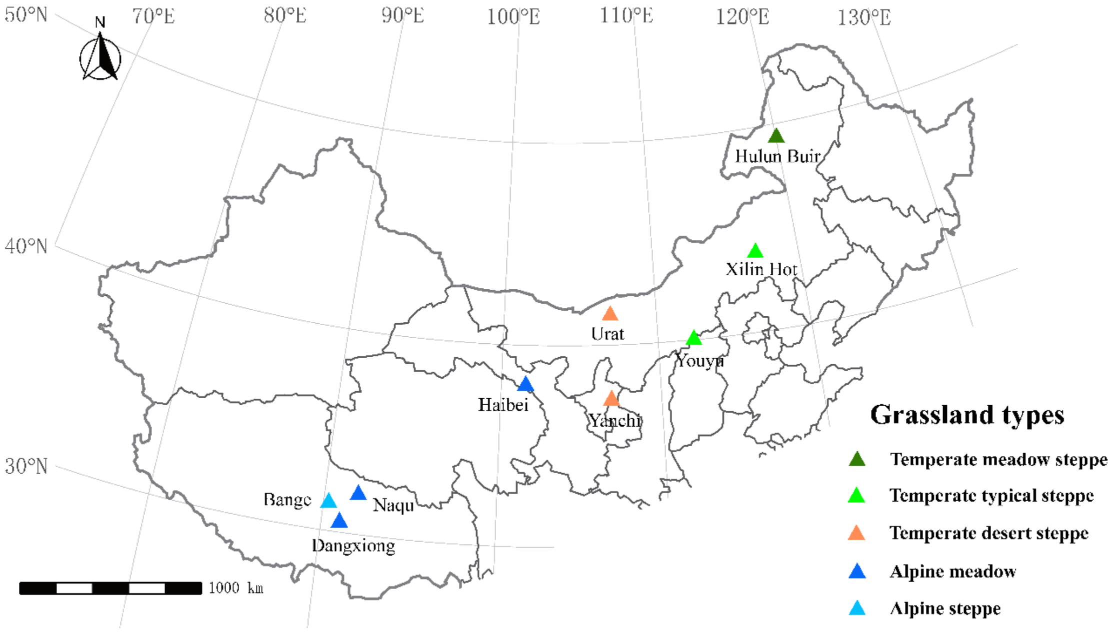

Fig.1 The location of nine grassland ecosystems

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Characteristics of metal-organic associations in *Sphagnum* wetlands

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Sphagnum wetlands are global hotspots of carbon accrual, which is commonly attributed to the accumulation of particulate organic carbon as decay-resistant *Sphagnum* litter. However, the buildup of mineral-associated organic carbon (MAOC), a more persistent soil organic carbon (SOC) pool, has rarely been investigated in *Sphagnum* wetlands, which may underpin long-term SOC stability under global changes. Here we employ both laboratory simulation experiments and large-scale survey to examine characteristics of metal-organic associations in *Sphagnum* wetlands. Our results suggest that Sphagnum acid significantly enhanced the reductive dissolution of iron (hydr)oxides in both wetland soils and synthetic iron-organic matter complexes, promoting the formation of poorly-crystalline iron (hydr)oxides and increasing metal-bound organic carbon (bound OC). Large-scale comparisons consistently indicted that *Sphagnum* fostered a remarkable accumulation of bound OC in SOC (22.5 ±0.6%; n = 118), higher than non-*Sphagnum* wetlands or the average of all other terrestrial ecosystems, via activating iron and aluminum (hydr)oxides in the soil. The unique phenolic and acidic metabolites of *Sphagnum* further strengthened metal-organic associations, leading to the dominance of bound OC in soil MAOC. Importantly, in contrast with limited MAOC sequestration potentials elsewhere, MAOC increased linearly with SOC accrual without signs of saturation in *Sphagnum* wetlands. Our findings indicate that *Sphagnum* act as an efficient 'rust engineer' that largely boosts the rusty carbon sink in wetlands. Given the much longer turnover time of MAOC (or bound OC), *Sphagnum*-induced MAOC accumulation may underpin wetland SOC stabilization in the long term.

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Soil bacterial community cannot explain changes in soil aggregation after long-term adoption of reduced tillage and green manure in a Mediterranean rainfed almond orchard

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Intensive use of machinery and tillage creates heavy pressure on agroecosystems by altering the soil physicochemical and biological characteristics, leading to structure degradation by breakage of soil aggregates. However, how microorganisms are involved in the maintenance of soil aggregation is still under research. In this study we aimed to assess the interrelationship between soil bacterial community structure, soil aggregation, soil organic carbon content and pools, and soil nutrients, in an orchards with 10 years implementing reduced tillage and reduced tillage plus green manure. The treatments were: i) conventional tillage (CT); ii) reduced tillage (RT); and iii) reduced tillage and diversification with *Avena sativa* and *Vicia sativa* (RTD). Results showed that the different managements had no significant effect on almond yields. RTD significantly increased total organic carbon (TOC), with an average content of 19.5 g kg^{-1} compared to 17.1 g kg^{-1} in CT. RTD also contributed to an increase in the fraction of soil macro-aggregates. Both RT and RTD significantly increased soil total nitrogen (NT) and particulate organic carbon (POC). The bacterial community significantly changed with management: RTD showed a higher relative abundance of the family Solirubrobacteraceae and the genera *Streptomyces* and *Solirubrobacter*. The bacterial community structure was explained by changes in TOC, POC, pH, and NT values. However, no soil aggregate fractions neither the mean weight diameter was significantly associated with the soil bacterial community. Thus, a combination of reduced tillage and green manure could represent an appropriate sustainable management for rainfed almond orchards in very fragile environmental conditions, due to an increase in soil organic matter, total nitrogen, and the higher presence of beneficial bacteria related to soil productivity. However, although there was a direct relationship between soil bacterial community and soil organic carbon content, a direct association between soil bacterial community and soil aggregation could not be found.

Session 2:

Soil structure as physical constraints of the interfacial reactions among minerals, organic matter, and microbes

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Association of organic carbon with different forms of iron and aluminium in Australian soils

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A strong association of organic carbon (OC) with iron (Fe) and aluminium (Al) oxides has been observed in several recent studies. However, the role of various species of Fe and Al in the preservation of OC in Australian soils remains poorly understood. To address this, we collected surface (0-20 cm) and sub-surface (20-40 cm) soil samples from sites across New South Wales, Australia. We hypothesised that short range order (SRO) minerals of Fe and Al are the major contributors to SOC preservation in soils. Soil samples were subjected to three separate extractions, i.e., sodium pyrophosphate (PP), ammonium oxalate (OX) and dithionite citrate bicarbonate (DCB), which respectively extract organo-metal complexes, poorly crystalline and short-range order (SRO) minerals and total metal phases (including organo-metal complexes, poorly crystalline and short-range order (SRO) minerals, and crystalline metal oxides). The extracted solutions were analysed for Fe and Al concentrations using inductively coupled plasma mass spectrometry (ICP-MS). Total organic carbon (TOC) concentration in the original soils and the residues (after multiple washings) after extraction was determined using a CHN analyser (vario MACO cube Elementar).

Dithionite citrate bicarbonate extracted the highest amount of Fe from the soils whereas maximum amount of Al was extracted by oxalate. The extraction sequence for Fe was: $Fe_{dcb} > Fe_{ox} > Fe_{pp}$ while the sequence for Al was: $Al_{ox} > Al_{dcb} > Al_{pp}$. The SOC was extracted in the sequence: $C_{dcb} > C_{pp} > C_{ox}$.

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Soil multifunctionality and soil microbial networks in response to agronomic interventions

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Current agricultural practices often rely on amendments and inoculants to target deficiencies in the soil and provide extra nutrients, focusing heavily on yield. Nonetheless, soil functions and microbial communities play a key role in maintaining the yield in the long term and, therefore, in sustainable agriculture. Functions such as carbon storage, nutrient availability, soil structure, water retention and pathogen suppression are known to have multilateral relationships with each other and microbial communities, yet it's poorly understood how these complex networks can be steered in a such a way that the functions are optimised, and soil resources are not depleted. This calls for a deeper causal understanding of soil functional networks to achieve more targeted biotic and abiotic interventions capable of improving soil health. Our study aims to (1) describe how next generation agricultural interventions affect both soil functions and microbial communities; (2) predict possible functional relationships that could be used to steer this complex system in a specific direction. To explore this, 3 different plant systems (monoculture grass, mixed grass and monoculture crop) were inoculated with 4 different bacterial and fungal consortium inoculants, furthermore, the crop system was also treated with 7 different inorganic and organic amendments. All systems were grown across 4 different soil types. The pot mesocosms were maintained under greenhouse conditions and soil samples were collected after 3 months to assess soil functions and microbial communities. Soil structure, carbon storage, nutrient availability, water retention and soil resilience were surveyed through an array of physical and chemical analyses while soil microbial communities were analysed through 16S rRNA and ITS sequencing. Next, soil functions and microbial communities' co-response to agronomic interventions was studied using SpeSpe, a co-occurrence network tool developed to link microbial community structure to soil function and EleMi, a network analysis tool that predicts causal relationships between the microbial network and soil functions. Here we demonstrate how these recently developed network-based approaches can help us answer which part of the microbial community must be steered to reach a certain function, thus guiding the use of existing agriculture tools in a novel, sustainable manner.

Effect of decomposer enriched City Waste Compost application on growth and Yield of broccoli.

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Waste is a major problem in main city of the Nepal which tends to increase with rapid urbanization, improved living standards and changing consumption patterns. Management of increasing amounts of solid waste has become a major challenge in many cities in developing countries. City compost produced at mechanical composting plants in Asian countries including Nepal are generally low in plant nutrients. Hence enrichment is necessary for improving nutrient status and quality of compost. Considering the nutritional significance, fast decomposition rate and quality of the compost the study was conducted to enrich the city waste compost with waste decomposers. The present study was undertaken to evaluate the decomposer enriched city waste compost on broccoli growth and yield.The study was done in two locations I.e. In Jitpur,Bara and in Malepatan,Pokhara. The study used a Randomized complete block design (RCBD) with eight treatments and 3 replications. Five types of decomposers namely prarambha dhulo, prarambha jhol,jeevatu, Sathi, and Sanjivani were used to decompose the city waste. The treatments were Control, NPK (Full dose of recommended fertilizer), FYM ,Compost 1 (Prarambha dhulo enriched). Compost 2 (Prarambha Jhol enriched), Compost 3(Jeevatu enriched), Compost 4(Sathi enriched)and Compost 5(sanjivani enriched) .The composting time lasted for 40 days.The results showed that , not all waste decomposer enriched compost showed good results .However, most of the waste decomposer enriched compost showed higher yield and other yield attributes as compared with control and chemical fertilizers in both location.

Key Words: Waste, Waste decomposer, Compost, Broccoli

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More processed organic matter is accumulated in soils with higher acidity in stands of *Cryptomeria japonica* and *Chamaecyparis obtusa*

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Abstract here

Several studies reported that, under higher soil acidity, particulate organic matter (POM) content increased while mineral-associated organic matter (MAOM) content decreased due to the decline in microbial activity. On the other hand, our previous study of *Cryptomeria japonica* forests showed that both POM and MAOM were more decomposed in surface soils with low acid buffering capacity (low-ABC, i.e., higher acidity), than in those with high-ABC, due possibly to higher fungal activity and lower organo-mineral association efficiency (Hayashi et al., 2023 Plant Soil). However, it remains unknown how tree species and soil depth determine the degree of decomposition of these fractions. We, therefore, aimed to clarify the effects of soil acidity, soil depth, and tree species on quantity and quality of POM and MAOM, with the ultimate goal of conserving soil organic matter in plantation forests.

We collected soil samples from three depths (0–10, 10–20, 20–40 cm) in 11 *C. japonica* stands and 7 *Chamaecyparis obtusa* stands with contrasting soil ABCs, which were density-fractionated into a light fraction (LF) mainly consisting of POM, a middle fraction (MF) mainly of MAOM, and a heavy fraction which is mostly minerals. Alkali extraction was conducted to LF and MF, and their extracts were analyzed by fluorescence excitation emission matrices-parallel factor analysis. For both tree species, LF carbon content (mg C g^{-1}) and stock (kg C m^{-2}) were not significantly different between the soil ABCs throughout the profiles. On the other hand, significant difference was found for MF carbon content and stock, which were 1.5 times higher in *C. japonica* or 2.4 times lower in *C. obtusa* in the low-ABC soils than in the high-ABC soils throughout the profiles. Using principal component analysis, ten fluorescence components were reduced to three principal components in terms of their origin, oxidative degradation, and highly decomposed structure. The three components implied that the quality of POM in the low-ABC soils was more oxidatively degraded than that in the high-ABC soils for both tree species, whereas that of MAOM in the low-ABC soils was more plant-derived/highly degraded in *C. japonica* and more microbially metabolized in *C. obtusa* throughout the profiles.

Earthworm legacy effect: initial stimulation of soil carbon mineralization and subsequent carbon stabilization by forming aggregates

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The role of earthworms in soil carbon (C) dynamics has been actively investigated. Yet their specific effects remain unclear especially for long-term soil C dynamics. Earthworm can have two functions: enhancing and inhibiting carbon mineralization. In this study, we thus aimed at assessing the temporal changes in earthworm effect by monitoring C mineralization during 1-week soil incubation with earthworm followed by 7-month incubation after removing earthworm. Soil microcosms were constructed using a silic (allophanic) Andosol with an endogeic earthworm species, *Eisenia japonica*, and incubated at 20°C under a constant soil moisture, and C mineralization was measured by monitoring CO_2. The incubation period was divided into five phases. Earthworm did not change the total soil carbon content at the end of incubation. Earthworm-treated soil promoted C mineralization during the first phase (40 days), even after earthworm removal. Surprisingly, earthworm enhancing effect on carbon mineralization continued for 40 days after the earthworm removal. Thus, earthworm mucus likely enhanced microbial activity during the first 40 days. However, the enhanced mineralization was gradually diminished during the third phase. Subsequently, soil carbon mineralization was inhibited during the last fifth phase. The earthworm-induced inhibiting effect on soil C mineralization was more pronounced in the incubation microcosms that had higher body-weight earthworms. The results implies that the individuals with larger bodies promoted more aggregate formation, thereby increasing physical protection of soil C within the aggregates. Our study revealed the dynamic legacy effect of earthworm: short-term stimulation of soil C mineralization by earthworm feeding activity and subsequent inhibition effects via soil aggregate formation.

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Organic matter characteristics in density fractions of organic horizons: A case study of high altitude in snowy mountain, northern Japan

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Abstract

Organic horizons develop thick in specific environments, such as cold and anaerobic environments, and are susceptible to climate change. In contrast to most studies related to organic matter (OM) in organic horizons focusing on its amount to estimate carbon storage, knowledge of OM decomposition and accumulation processes is still insufficient. Recent studies have increased attention to the role of inorganic materials, transported through various pathways, in OM accumulation to estimate future dynamics of carbon in organic horizons (e.g., Fe oxide in histic organic horizons) because OM associated with inorganic materials can be protected from microbial degradation. However, it is not clear how OM shows different biogeochemical characteristics in the varying degrees of associations with inorganic materials in organic horizons. The objective of this study is to elucidate OM characteristics by density fractionation, a commonly used method in mineral soils to fractionate soil particles by OM-mineral associations. To achieve the research objective, we selected organic horizons in the high altitudes of snowy mountains in northern Japan, which received rich inorganic materials, such as volcanic ash and Asian dust.

We used three soil profiles selected from Mt. Chokai, Mt. Kurikoma and Mt. Makihata. Freeze-dried organic horizon samples were separated into three fractions: coarse light fraction (coarse LF: < 1.6 g cm^{-3} and > 0.5 mm), fine light fraction (fine LF: < 1.6 g cm^{-3} and < 0.5 mm), and heavy fraction (HF: > 1.6 g cm^{-3}). Physical feature of isolated fractions was examined by a microscopic observation. Organic carbon (OC), total nitrogen (TN), and pyrophosphate and oxalate extractable metal (Alp, Fep, Alo, and Feo) in isolated fractions were measured. Cabon functional groups were assessed by solid-state ^{13}C NMR spectroscopy.

OM of isolated fractions showed different properties based on OM associated minerals, C/N, and carbon functional groups. The factor contributing to the fractionation of OM into HF was its association with crystalline minerals or reactive Fe based on the result of SEM observations and selective dissolution experiments. OM attached crystalline minerals were found in SEM images of HF. The Fep/OC ratio was high in HF compared with fine LF, indicating reactive Fe accumulated preferentially in HF. However, the Alp/OC ratio was the same between fine LF and HF. C/N of OC decreased from coarse LF to HF, indicating more microbial degradation. Carbon functional groups of HF was high O-alkyl C proportions compared with fine LF. This result suggests that it is possible that O-alkyl C is stabilized by crystalline minerals or reactive Fe in HF. From these results, we proposed that OM in each isolated fraction showed different biogeochemical properties in organic horizons.

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Evaluating Fire Exclusion and Grassland Degradation Effects on Soil Aggregates and Carbon in Afromontane Grasslands: Lessons from Cathedral Peak, South Africa

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Afromontane grasslands in temperate high-rainfall regions of South Africa are huge reservoirs of soil organic carbon (SOC) that rely on fire for their vitality. Understanding the impact of Afromontane grassland management and degradation on soil aggregate stability and the associated carbon is crucial for grasping the potential for carbon sequestration and stabilization. Soil aggregates play a pivotal role in governing various soil and ecosystem functions, encompassing SOC levels, soil water retention capacity, and soil fertility. This study investigated the distribution of water-stable aggregates and aggregate-associated C in relation to fire exclusion, and post-afforestation grassland degradation in the Cathedral Peak Research Catchments, South Africa. Soil samples collected at various soil depths revealed that macro-aggregates were more dominant than micro-aggregates in all sites, indicating a state of aggregation and relative stability against soil erosion. The grassland showed a greater abundance of macro-aggregates and stored more intra-aggregate carbon compared to the afforested site. This implies that soils in the grassland are more aggregated and offer a physical protection to SOC against microbial degradation and loss. This underscores that grasslands managed through infrequent fires promote soil aggregation, ultimately enhancing the physical protection of SOC reserves. The impact of grassland degradation on water-stable aggregates became apparent in the degraded catchment, where there was a higher presence of micro-aggregates on the eroding slopes (top and middle slopes) in contrast to the natural grassland catchment. The process of soil erosion involves the detachment and transportation of soil particles, which leads to the disintegration of soil aggregates, thereby yielding a higher proportion of micro-aggregates compared to macro-aggregates in these eroding slopes. Nevertheless, there was evident re-aggregation observed in the lower slope position of the degraded catchment. Interestingly, despite substantial soil losses occurring in eroding areas such as the top and middle slopes, large amounts of SOC stocks remain protected within macro-aggregates. This suggests that the degraded catchment retains a significant potential for C sequestration through dynamic replacement, provided that there are suitable rehabilitation efforts. The results of this study propose that physical protection of SOC within macro-aggregates may serve as one of the potential mechanisms contributing to the elevated SOC levels observed in these Afromontane grasslands.

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Unveiling Substantial Impact of Rice Transplanting Date on Net Annual Global Warming Potential and Productivity during Cropping and Fallow Seasons in a Mono Rice Paddy Field

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Shifting rice transplanting dates can influence rice growth and biomass by altering meteorological parameters and flooding periods, which can significantly affect greenhouse gas (GHG) emissions throughout the entire year, including rice cropping and fallow seasons. Nevertheless, no comprehensive evaluation has been conducted so far. This study was to investigate the potential impact of shifting rice transplanting dates and deciphering their influencing factors on affecting greenhouse gas emissions and maintaining rice productivity in a mono-rice paddy field during a whole year (cropping and fallow seasons). GHG emissions including CH_4, CO_2 and N_2O, annual net global warming potential, and rice productivity were investigated in the field condition. Two different rice cultivars (late-maturing and early-maturing) were transplanted at four different dates on May 10 (Time1), May 25 (Time2) as the locally recommended transplanting date (RTD), June 10 (Time3), and June 25 (Time4). Regardless of rice cultivar, the highest CH_4 emission was observed in the early transplanting (Time1), and significantly decreased by 24-87% with delaying transplanting dates in rice cropping season. The significant reduction of CH_4 might be related to the changes in rice growth characteristics and overall cultivation environments including the shortened heading date and reduced flooding periods as well as decreased cumulative soil and air temperature. During the rice cropping season, CH_4 accounted for approximately 90% of total GHG emissions, while CO_2 and N_2O were negligible, indicating CH_4 is a major contributor to overall global warming in the rice paddy ecosystem. On the other hand, during the fallow season, CO_2 emissions were predominantly emitted due to maintaining aerobic conditions, while CH_4 and N_2O were negligible. CO_2 emissions were observed to be highest in early transplanting (Time1) and significantly decreased with delayed transplanting dates during the fallow season. Interestingly, root biomass was highest at Time1 and gradually decreased with delayed transplanting after the rice harvest. A strong positive relationship was observed between CH_4 and CO_2 emissions and root biomass remained after the harvesting, suggesting their strong contribution as supplying carbon source for CH_4 and CO_2 emissions, which might have a strong legacy effect in the successive rice cropping seasons. The rice grain yield was gradually improved with delayed transplanting, reached the highest level at Time3, and then slightly decreased at Time4. However, there was no significant yield loss as compared to the RTD (Time2). Conclusively, shifting the rice transplanting date could be a simple, promising, and pioneering way to effectively mitigate GHG emissions without significant productivity loss in a paddy field ecosystem.

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Optimal dispersion methods for single cell genomics analysis of single soil aggregate

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Each single soil aggregate may be considered as a discrete habitatdistinguished by a degree of adhesion among soil particles. The interior of macro-aggregates is limited in oxygen diffusion. Thus, bacteria possessing N_2O reductase (*nosZ*), an O_2 sensitive enzyme, are likely to inhabit in these aggregates. In order to obtain genomic information on *nosZ*-possessing bacteria by single cell genomics (SCG) analysis, here we examined soil extraction methods to obtain sufficient amounts of viable bacteria from a small sample volume (i.e. single aggregate) with a focus on optimal dispersion technique (bead vs. ultrasonication).

We assesed pilot tests examining the extraction and aggregate dispersion techniques (mechanical shaking, zirconia beads shaking, sonication) as well as the purification of dispersed soil suspension (the sequential washing, Nycodenz purification) with estimation of viable cell number. Using the optimized extraction methods, which combined beads or sonic dispersion and sequential washing, we assess whether the extracted cells were representative of the soil by comparing cell number and microbial community between the supernatant and the soil residue using qPCR and amplicon analysis, and then performed SCG analysis.

By qPCR and amplicon analysis, we found that the decrease in the species number in the second supernatant (relative to the residue) was less than 40% while the number of bacteria in the supernatant was two orders of magnitude lower than in the soil residue. The bacterial communities of the supernatants and residues were more similer in sonic treatment than in beads treatment. By SCG analysis, we found that two dispersion methods differed in data quality and taxonomic and functional diversity of the bacteria, which also showed trade-offs between the quality and the diversity in these dispersion techniques. All aggregates held similar set of N-related functional genes. However some variations among single aggregates were detected.

We were able to conduct SCG analysis of single soil aggregates for the first time. Furthermore, our results suggest that ultrasonic dispersion was more adequate cell extraction method for the recovery and analysis of viable bacteria (especially *nosZ* bacteria) from single aggregates for the studied soil.

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Effects of continuous cropping soil on growth and tissue analysis of Eustoma

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Abstract

Soil samples were taken from continuous cropping soil in Huwei, Yunlin to analyze the soil physical and chemical properties. The soil was then planted with *Eustoma grandiflorum* ‘Croma III White’ for growth investigation and plant analysis. Results showed that the continuous cropping soil is sandy clay loam with a porosity of 28.6%, pH value of 7.9, and EC value of 1.54 $dS \cdot m^{-1}$. The levels of available phosphorus, potassium, calcium, and magnesium in the soil were all more than three times higher than the recommended amounts, indicating excessive fertilization leading to high salinity in the soil. Continuous cropping soil with organic fertilizer as a way of soil improvement effectively reduces the EC value (0.48 $dS \cdot m^{-1}$), but the improvement effects on other physicochemical properties are not significant. After planting in the continuous cropping soil for 28 days, compared to the control, the plants appeared shorter with noticeably smaller leaves, suggesting a reduction in leaf area. The difference in plant height was mainly influenced by internode length. Plant analysis of the tested variety showed that apart from iron elements, both macro and micronutrients were within the recommended range based on previous studies. The content of malondialdehyde (MDA) in root tip cells of plants grown under continuous cropping soil ranged from 32-40 $nmol \cdot g^{-1}$ which was higher than that of the control group (18-28 $nmol \cdot g^{-1}$). Therefore, salt accumulation in soils may be one of the reasons causing obstacles to *Eustoma grandiflorum* growth under continuous cropping conditions.

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Inhibition of radiocesium adsorption on 2:1 minerals by soil organic matter and interlayer Al polymer in the arid western United States

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Specific adsorption of radiocesium (RCs) on 2:1 minerals, which greatly reduces the mobility of RCs in soil, has been found to be inhibited by organic matter (OM) coatings on the minerals and by the interlayering of Al polymers. However, because previous studies were constrained to soils in temperate region, the climatic impacts on the magnitude of the inhibitory effect were not investigated. Therefore, the objectives of this study were to clarify the inhibitory effect of OM and Al polymers on RCs adsorption in soils developed in an elevational series in the arid zone and to compare the magnitudes with those in temperate regions.

Soils were collected from the surface to 12 cm in 3 cm increments at four sites along an elevation series of desert-meadow-pine-mixed conifer forest vegetation succession from low elevation (1006 m) to high elevation (2413 m) on Mount Lemon (32° 25 N, 110° 44 W), Arizona, USA. Wet-sieved < 20 µm particles were isolated from untreated samples, untreated samples treated with H_2O_2 to remove OM, and OM + Al samples treated with a chelating reaction using citrate ions to remove Al polymer, and total carbon (TC) content, XRD diffraction patterns, and RCs interception potential (RIP) were measured for each sample. In addition, to verify the magnitude of the interaction between minerals and OM for some samples, the magnitude of the area of mineral coverage by OM were examined from the difference in specific surface area (SSA) of the samples before and after OM removal.

TC content of the untreated samples was 8.7 ~ 97.8 g/kg and tended to increase toward the surface and higher elevations. More than 80% of OM was removed by the H_2O_2 treatment. The XRD results confirmed the original absence of Al polymer, reflecting the soil pH of about 6. Neither experimental removal of OM nor Al polymer did not increase RIP values. In other words, no inhibition of RCs adsorption by OM or Al polymers was demonstrated, in sharp contrast to the temperate soils in previous studies. No inhibition by Al polymer is reasonable since it is originally not present. No inhibition by OM despite of its abundance was not expected but probable because SSA was not increased after the OM removal treatment. Mineral surfaces were not covered by OM coatings, and therefore accessible for Cs^+ in adsorption. Thus, it is clear that 2:1 minerals especially at their interlayers weakly interact with organic matters in arid regions such as Arizona, which causes an advantage in the RCs adsorption capacity of 2:1 minerals being maximized under natural conditions.

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Development of solid-phase fluorescence (SPF) excitation-emission matrix (EEM) spectroscopy for non-destructive and non-extractive analysis of soil organic matter

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The possibility that humic substances (HSs) become artificial substances losing their original structure after extraction from soil or a sediment by an alkaline solution is controversial [1]. The authors' research group has been developing solid-phase fluorescence (SPF) excitation-emission matrix (EEM) spectroscopy with the aim of non-destructive and non-extractive analysis of soil organic matter. This is expected to be an effective technique for directly observing the interaction of minerals, organic substances and microorganisms in soil. In the previous publications, the authors first reported the results of applying this method to soil [2]. Second, a correction by an empirical formula for inner-filter effect-like decrease in fluorescence of a model solid sample by a fluorescent protein and colorants was proposed [3]. Third, the effect of the difference of the state on the EEM spectrum was examined by comparing EEM in the solid state and the solution state using model fluorescent materials [4]. Finally, in order to confirm the difference in EEM by actual NOM, we prepared and analysed clay-HS complex. Clay (Na-montmorillonite) suspensions and fulvic acid (FA) solutions were mixed, shaken and centrifuged, and precipitates were washed with pure water and freeze-dried to obtain clay-HS complexes. SPF-EEM spectra were measured by NanoLog (HORIBA) following the previous study [2]. EEM spectra of HS aqueous solutions and alkaline extract solutions from the complexes were also measured. In the previous research on SPF-EEM spectra of HS powder, no fluorescence peak was observed. This was tentatively explained by the inner-filter effect (IFE) due to the coloring of the HS itself. However, in the present study, an EEM pattern was observed in HSs in powdered solid state. Moreover, the position of the fluorescence peak shifted to the longer wavelength side in the order of solution, complex, and solid states. The EEM spectrum of the extract obtained by alkaline solution from the complex showed an EEM pattern similar to that of the original HS aqueous solution. Therefore, structures of HSs in the dissolved, complex (adsorbed to clay), and solid sates are considered to be different.

[1] T. Ohno et al. (2019) *J. Environ. Qual.* 48, 1561–1564.
[2] Y. Nakaya et al. (2020) *Spectrochim. Acta Mol. Biomol. Spectrosc.* 233, 118188.
[3] Y. Nakaya et al. (2023) *Spectrochim. Acta Mol. Biomol. Spectrosc.* 285, 121885.
[4] Y. Nakaya et al. (2023) *Talanta* 270, 125566.

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Influence of land cover and soil type to Iron and Aluminum-bound organic carbon: A key for storage potential and persistence mechanism of organic carbon

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Abstract

Soil is the largest terrestrial pool of organic carbon and is a promising climate change mitigation strategy through sequestration of (C) in soil organic matter (SOM). SOC has often been separated into two operational physical fractions by size; particulate organic carbon (POC;53-2000µm) and mineral-associated organic carbon (MAOC;<53µm), to improve our understanding of the storage and persistence of SOC. The POC and MAOC are fundamentally diverse in terms of the mechanisms of formation, persistence, and function. The formation of MAOC is widely known to persist for decades to centuries. However, the persistence of the soil to sequester carbon relies on the mineral association, including iron (Fe) and aluminum (Al), which have critical sorption surfaces and are thought to protect OC. To date, no studies have reported the Fe and Al-bound OC on the two important land cover (paddy rice and forest) and the soil types (soil orders) in Taiwan. A total of 134 soil samples were collected across the country and fractionated. The Fe and Al concentrations and carbon in each fraction were quantified. Results unveiled that MAOC increases linearly with SOC with varied land cover and soil types. We found considerable differences in the MAOC content of the land cover and soil types. Forests have proportionally more MAOC than paddy rice. The soil type strongly affected the relationship between poorly crystalline [$Fe_{o(MAOM)}$ and $Al_{o(MAOM)}$] oxides and MAOC. The $Fe_{o(MAOM)}$ (r=0.44, $p<0.001$) and $Al_{o(MAOM)}$ (r=0.71, $p<0.05$) positively correlated with MAOC in the Mollisol/Inceptisol/Vertisol soil, whereas $Fe_{o(MAOM)}$ (r=0.92), $Al_{o(MAOM)}$ (r=0.93) with MAOC ($p<0.001$) in Ultisol/Inceptisol, in paddy rice and forest, respectively. On the same trend of land cover and soil order, POC might strongly contribute to the Fe_o /$Al_{o(MAOM)}$-bound OC. The POC linearly accrued with MAOC, (slope=0.82, 0.93; R^2 =0.68, 0.87; r= 0.83, 0.93) in paddy rice and forest ($p<0.001$), respectively. These findings highlight that land cover and soil type influence the Fe_o/Al_o-bound OC along with the significance of SOC fractionation towards storage potential and persistence mechanism gap of MAOC. On the contrary, these raise imperative questions: How can MAOC in paddy rice increase and persist regarding soil types, and do forests acquire MAOC saturation?

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Pore-scale modelling of soil microbial respiration under drying/rewetting cycles of variable drought lengths

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With climate change, temperate ecosystems will undergo more frequent and intense droughts (IPCC, 2019) that may trigger large peaks of CO_2 emission upon soil rewetting. In semi-arid ecosystems, these emissions, known as the Birch effect (Birch, 1958) can contribute significantly to the annual carbon budget (Barnard et al., 2020). Several mechanisms, not exclusive, have been hypothesized to explain the Birch effect: continuous enzymatic depolymerisation of soil organic matter during drought, increase of soil microorganisms mortality, adaptation of soil microorganisms that develop osmoregulation stategies to cope with water stress, and physical deprotection of organic matter during drying/rewetting cycles. We used a 3D pore-scale model of decomposition of soil organic matter by bacteria (LBioS model, Vogel et al., 2015) to simulate five successive drying/rewetting cycles of variable drought lengths (1 week and 6 weeks). Spatially distributed bacteria colonies, randomly located within a 3D pore space extracted from tomographic images of soil, experienced variable moisture conditions and activated either dormancy or osmoregulation (Manzoni et al., 2014). We discuss results in view of the conceptual choices made to cope with i) simplification of processes due to computational cost issues (enzymes were assumed ubiquitous in the pore space, the variations of water saturation are represented as successive snapshots) and ii) the image resolution that for instance hindered diffusion of soluble carbon in water films and over-exposed bacteria colonies to dryness.

Barnard RL, Blazewicz SJ, Firestone MK (2020). Rewetting of soil: Revisiting the origin of soil CO2 emissions. *Soil Biol Biochem* 147 107819. 10.1016/j.soilbio.2020.107819

Birch H (1958). The effect of soil drying on humus decomposition and nitrogen availability. *Plant Soil* 10, 9-31. 10.1007/BF01343734

IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems Climate change and Land, August 2019

Manzoni S, Schaeffer SM, Katul G, Porporato A, Schimel JP (2014). A theoretical analysis of microbial eco-physiological and diffusion limitations to carbon cycling in drying soils. *Soil Biol Biochem* 73, 69-43. 10.1016/j.soilbio.2014.02.008

Vogel L, Makowski D, Garnier P, Vieublé-Gonod L, Coquet Y, Raynaud X, Nunan N, Chenu C, Falconer R, Pot V (2015). Modeling the effect of soil meso- and macropores topology on the biodegradation of a soluble carbon substrate. *Adv Water Resour* 83, 123-136. 10.1016/j.advwatres.2015.05.020. insu-01170155v1

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Prediction of soil bacterial community driving nitrogen-cycling in no-till and tilled upland fields with *Azoarcus*-inoculated rice

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Inoculation of rice seeds with *Azoarcus* sp. strain KH32C has been shown to increase the early growth of rice and affect soil bacterial community in low nitrogen input paddy field. In this study, we investigated rice growth and soil bacterial communities in no-till and tilled upland fields in which KH32C-inoculated rice was cultivated.

KH32C was inoculated onto pregerminated upland rice seeds (cv. Hitachihatamochi). KH32C-inoculated (KH) and non-inoculated (NI) rice seedlings were transplanted to conventionally tilled upland field (TL) and no-tilled upland field half a year after the last tillage (NT) in Ibaraki, Japan. Rice growth investigation and soil and gas sampling were conducted at 25, 49, 75, and 109 days after transplantation (DAT). Water filled pore space (WFPS) of NT soil was higher than that of TL soil on each investigated day. The aboveground biomass of upland rice in NT from 25 to 109 DAT decreased by 51-81% than that in TL. Rice grain yield in NT-KH was higher than that in NT-NI. SPAD value of rice leaves of NT-KH was higher than that of NT-NI at 25 DAT. Soil ammonium nitrogen content in NT-KH and nitrate nitrogen content in TL-KH were lower than those in NT-NI and TL-NI, respectively, at 25 DAT. N_2O was emitted from soil only at 25 DAT; the emissions were higher in NT soil than TL soil (NT-KH, 8.2 μgN m^{-2} h^{-1}; NT-NI, 3.8 μgN m^{-2} h^{-1}; TL-KH, 0.9 μgN m^{-2} h^{-1}; TL-NI, 1.1 μgN m^{-2} h^{-1}). In addition, amplicon sequencing analysis based on bacterial 16S rRNA gene was performed on soils sampled at 25, 49, and 75 DAT and on uncultivated soils sampled at 13 DAT. In NT-KH, the relative abundance of phylum Verrucomicrobia increased and phylum Actinobacteria decreased compared to NT-NI. The metagenome analysis by predicted functional profiles using PICRUSt2 based on KO (KEGG Orthology) database showed that the functional relative abundance of nitrite reductase genes was different between NT and TL; *nirS* was higher in NT soil (NT, 0.24-0.66 copies/100 cells; TL, 0.17-0.40 copies/100 cells) and *nirK* was higher in TL soil (NT, 5.74-7.73 copies/100 cells; TL, 6.14-7.55 copies/100 cells). At 25 DAT, WFPS had positive correlations with the functional relative abundances of genes related to denitrification and dissimilatory nitrate reduction to ammonium (DNRA), soil ammonium nitrogen content, and N_2O flux, indicating that the anaerobic soil condition made by no-tillage promotes denitrification and DNRA. Our results also indicated that KH32C inoculation improved nitrogen use efficiency and growth of rice and affected the bacterial community in no-tilled upland soil.

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Important indicators for assessing organic carbon sequestration in soil aggregates for building high quality carbon stocks

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Soil aggregation is critical for increasing soil organic carbon (SOC) sequestration and ecosystem services. Assessing SOC quality indicators, in addition to quantitative assessments in aggregates, can provide further insights on conservation practices and their ability to increase stable SOC stocks. Evaluating microbiome structure is also crucial, especially in sandy soils, which largely depend on microbial interactions for aggregation. The objective of this study was to analyse soil aggregation and SOC pools within aggregate fractions to evaluate the long-term (>50 years) impacts of different grazing and fertilization practices in improved grazing lands (IGLs) in comparison to a minimally managed native pine forestry site (FS) within subtropical humid climate. Soil cores collected from a 0–60 cm soil profiles were separated by depth, which were further separated into aggregate fractions through dry and wet sieving methods for comparison. Individual dry sieved aggregate fractions were analysed for SOC content, CN ratio, fungal to bacterial ratio (FBR) and microbiome structure. Additionally, for assessing quality of SOC sequestration, SOC in aggregates were separated into particulate organic carbon (POC) and mineral occluded carbon (MOC).

Results from this study provided several important insights. A method comparison study revealed that wet and dry aggregate separation were not significantly different. Thus, the dry aggregate method may be more reliable as samples could be used for microbiome estimation. In grazing systems, more MOC was formed compared to a pine forestry system. High grazing pressure increased aggregation but failed to retain higher SOC and formed lower MOC, revealing sensitivity of these pools to poor grazing management. Therefore, soil aggregate stability as a standalone metric is not a good indicator of SOC stability in grazing systems. Both POC and MOC pools were different between aggregates and experimental factors, along with fungal-to-bacterial ratio and microbiome structure. Considering both quantitative and qualitative assessments of SOC in aggregates, it was clearly identified that low-intensity grazing with reduced nitrogen input and the integration of legumes is an efficient approach, comparable to a native forest system, for building high-quality carbon stocks.

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High-resolution monitoring of plant root and soil interactions enabled by a distributed fiber optic sensor

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Abstract:
A distributed fiber optic sensor (FOS) measures the physical properties, such as temperature and strain, along the structure to which it is attached. By spatially encoding and enhancing the sensitivity of FOS embedded in the soil, we have developed a non-destructive real-time underground monitoring system to detect phenomena as fine as plant root growth. When deployed in the field, the system can simultaneously track various underground events such as diurnal heat dissipation, soil compaction, and relaxation. Interestingly, the soil “relaxation” occurs during rainfall only in the presence of plant roots, suggesting the feedback interactions between plant roots and soil as plants prefer loose soil for easy penetration. Our device records long time-series measurements of temperatures and strain distribution of the underground space, typically up to 0.35m in depth. Strain and temperature signals from different underground events can be separated from the specific occurrence patterns. For example, the effect of the sun can be easily extracted using a band-pass filter and spatial distribution of peaks concentrated near the surface. Our FOS device can offer new approaches to studying soil-organic matter interactions, such as mechanical feedback loops and climate effects, empowered by unprecedented spatiotemporal resolution and high sensitivity, while the experimental span can be extended up to months.

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Drought impacts on soil pore structure and biochemical properties of a shortgrass steppe ecosystem

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Recent climatic changes have increased the unpredictability of rainfall events with a heightened probability of droughts, thus influencing the belowground carbon sequestration. Soil structure is shaped by physical, chemical, and biological processes and their interactions. Droughts are linked to the loss of soil structural stability, reduced pore-water connectivity, and organic carbon transport, therefore affecting soil microbial activity. The protection of carbon within the soil matrix is majorly driven by its accessibility to microbial decomposers and is also determined by the abundance of soil pores of a specific size range. In this study, we investigated the effects of drought on soil pore characteristics like pore size distribution, porosity, distances to pores, and biochemical properties such as microbial biomass carbon, ergosterol content, and soil organic carbon. The study site was a Long-term Ecological Research experiment of a short grass steppe ecosystem with treatments of 66% rain exclusion (regarded as drought) and control plots in a randomized complete block design. Dominant plant species include C4 grasses, blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), and C3 plains prickly pear cactus (*Opuntia polyacantha*). This study aims to understand the importance of soil structure in interaction with organic matter and microbial activity. Intact soil cores of 5 cm in height by 5 cm in diameter were collected from 5-10 cm of soil depth to derive the soil pore characteristics using the X-ray computed microtomography technique (X-ray µCT, resolution of 18 µm). Bulk and intact soil samples were collected during the fifth year of the treatments in place.

The study arrived at interesting results of increased pore volumes of size range 30-300 µm and 48.1% higher image-based porosity in the drought soils. However, the microbial biomass and ergosterol contents were 51% and 47%, respectively, higher in the control soil than in the drought. Soil organic carbon content is not significantly different between drought and control treatments. Furthermore, the bulk soil samples were analyzed for base chemical properties such as pH, cation exchange capacity, available phosphorus, exchangeable potassium, magnesium, and calcium. Overlaying X-ray µCT derived soil pore characteristics with microbial attributes provides broader insights into understanding the intricate relationship between soil structure, microbial activity, and ecosystem functioning. The findings from this study will be beneficial in identifying suitable management strategies for drought tolerance to mitigate the adverse effects of climate change.

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The Vulnerability of Soil Organic Carbon in Urban Soils and Its Relation to Microbial Functions

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There is a growing interest in carbon absorption within urban ecosystems. For accurate carbon absorption monitoring, reporting, and verification (MRV), understanding the changes in plant and soil carbon stocks is important. Plant carbon stock is known to increase in urban ecosystems, although its rate is slower than that of natural ecosystems. However, there is a lack of studies explaining the changes in urban soils' organic carbon (SOC) stock, especially the C output flux. In this study, we aimed to investigate C output in urban soils by comparing the biological and physical stability of SOC in urban greeneries and natural grasslands. We hypothesized that 1) the higher pH in urban soil increase oxidase activity, which also stimulates hydrolase activity, resulting in high C output, 2) physically unprotected structures of urban soils could leave soil C more vulnerable to loss or decomposition rather than being stored. The soil samples were collected in natural grassland (GL), urban park (UP), urban green strip (UGS), and urban roadside trees (URT) ($n = 36$). We measured the SOC stock of four different soil fractions: light fraction carbon (LFC), macro- and micro-aggregated occluded particulate organic carbon (macroPOC and microPOC), and mineral-associated organic carbon (MAOC). The SOC vulnerability was calculated by dividing the ‘LFC + macroPOC’ by ‘microPOC + MAOC’. Subsequently, we analyzed soil bulk density (BD), pH, and microbial variables including basal respiration, hydrolase and oxidase activities, and glomalin-related soil protein (GRSP). The results showed that the highest SOC vulnerability appeared in the URT, followed by UGS, UP, and GL in the order. The basal respiration and specific enzyme activities (hydrolase or oxidase activities/SOC stock) were also greater in urban soil, particularly in URT. Furthermore, the GRSP content, which could contribute the aggregate formation, was significantly lower in the URT and UGS compared to the UP and GL. These results implied that the SOC is less physically protected and continuously depleting in urban greeneries. To explain how the environmental variables and microbial activity contributes to changes in SOC vulnerability, we conducted structural equation modelling (SEM). The SEM results indicate that the higher pH and BD of urban soil increase microbes' oxidase and hydrolase activities, resulting in the consumption of existing SOC. In summary, management strategies in urban greenery should not only focus on vegetation but also on managing carbon outputs from soil to ensure sustainable carbon absorption.

Session 3:

New concepts and approaches: Methodological and conceptual advances

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Dynamics and vulnerability of mineral-organic associations in the rhizosphere: mechanisms, controls, and response to change

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Up to 90% of a soil's organic carbon (C) content is stored in organic compounds intimately associated with reactive soil minerals. Such mineral-organic associations (MOAs) can protect C compounds against microbial or enzymatic attack. Commonly held concepts suggest that MOAs, once formed, protect enclosed C and exhibit resistance to environmental disturbance. Plant roots and associated microbes in the rhizosphere, however, have a well-known ability to transform minerals through dissolution and exchange reactions. Yet, the impact of such root- and microbially-mediated reactions on MOAs and C protected therein remains elusive. Here, we develop a conceptual framework for the vulnerability of MOAs to rhizosphere processes and discuss their vulnerability to global change. We will (i) identify rhizosphere processes acting as drivers of MOA disruption, (ii) introduce the biogeochemical mechanisms by which roots may disrupt MOAs, (iii) examine ecosystem-scale controls on root-derived MOA disruption, and (iv) discuss potential global change responses. We propose that conceptual and numerical models explicitly consider the dynamic balance between both formation and disruption of MOAs in the rhizosphere. A more nuanced understanding of how this balance varies across ecosystems and under climate change will allow us to better project soil carbon-climate feedbacks.

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Effect of agricultural management practices on soil structural stability and organic matter deprotection during drying-rewetting cycles

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Increasing drought conditions as a result of climate change are expected to cause more frequent and intense drying-rewetting (DRW) cycles in soils. Peaks of CO_2 emissions released from the soil to the atmosphere upon rewetting have been well documented. One hypothesis for this carbon release is the physical deprotection of organic matter in soils due to modifications in pore network morphology. Soil structural stability during DRW cycles depends on soil properties (e.g. texture, carbon content), but should also depend on soil management practices in agroecosystems.

This work aims to reveal for the first time the physical deprotection of organic matter in natural soils during DRW cycles using synchrotron-based X-ray imaging. Soil samples were collected from the 2-5 cm layer of two Luvisols under conventional and conservation agriculture respectively. The samples were air-dried and broken manually into aggregates of 2-3 mm, and their organic matter was stained with Osmium. 18 aggregates were subjected to 3 DRW cycles and scanned at 1.3 µm resolution before and after rewetting.

More intense deformation was observed under conventional agriculture compared to conservation agriculture during the DRW cycles. Aggregates from conservation agriculture show thinner cracks and better structural recovery upon drying. Aggregates from conservation agriculture also contain more Osmium-stained organic matter. Further steps of this project will quantify interactions between the organic matter and the changing pore network during DRW cycles, and infer new relationships between soil organic matter decomposition and soil structure dynamics.

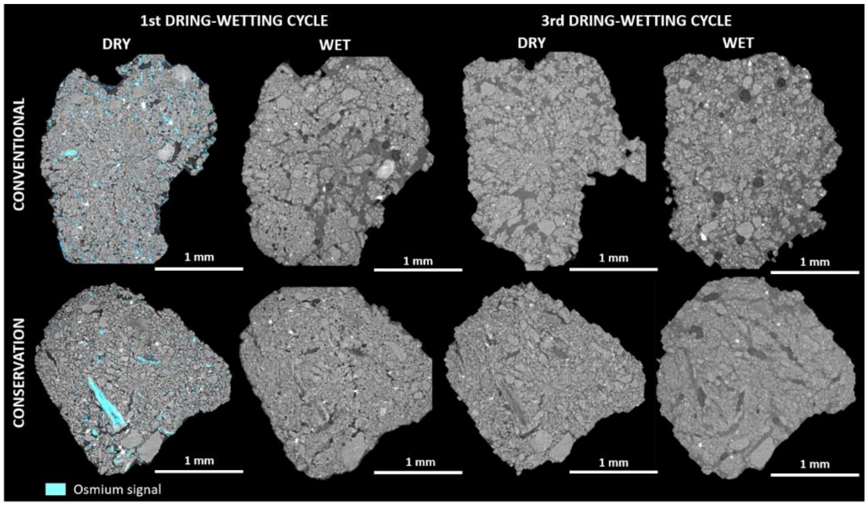

Figure: Aggregate structure before and after rewetting (DRW1 and 3) for conventional and conservation agriculture

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Validating Phosphate Solubilising Bacteria Ability to Solubilise Inorganic Phosphates in Soil Slurry Medium

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Malaysian agricultural soils predominantly comprise Ultisols and Oxisols. These soils are characteristically acidic (pH 3 to 5) and are extensively weathered due to tropical climatic conditions (i.e., high rainfall and temperatures throughout the year) and inherently low in fertility. Phosphorus (P) is one of the major macronutrients needed for oil palm growth and yield, while its availability for crop uptake is severely restricted due to immobilisation by sesquioxides, thus rendering P unavailable, precipitating with aluminium and iron ions at pH levels below 5.5 and with calcium ions above pH 7. In achieving optimal P nutrition in oil palm, P is typically supplied by over-applying phosphate rock (PR) fertilisers, which aim to surpass the soil's P-adsorption capacity. Notwithstanding, liming is also carried out to elevate soil pH and thus neutralise the sesquioxides of iron and aluminium.

The utilisation of phosphate-solubilising bacteria (PSB) presents an innovative alternative, transforming unavailable P into forms accessible to plants, thereby promoting growth. Nevertheless, substantial gaps exist in research validating the effectiveness of PSB in enhancing the availability of P in soil. This study aims to establish a method for assessing the phosphorus solubilising capabilities of ten PSB isolates in controlled environments using soil slurries with various inorganic P sources ($FePO_4$ and Ca_3PO_4). Soil samples from three oil palm estates were examined for their P fixation capacities using P adsorption/desorption isotherms, calculated using the Langmuir equation, leading to the selection of two soil types, Prang soil series (Typic Hapludox) and Rengam soil series (Typic Kandiudult), representing soils with high and moderate P-fixing soils. The investigation involved testing ten PSB isolates' capacity to solubilise Fe-, Al- and Ca phosphates, which led to the shortlisting of four isolates exhibiting high activity, increasing available P. The solubilising rates across both soil types ranged from 2.80 to 54.8 mg/L for $FePO_4$ (equiv. to a 2.2 to a 9.7-fold increase against the control) and 17.4 to 52.0 mg/L for Ca_3PO_4 (1.3-3.8 fold increase). However, all isolates displayed minimal activity against $AlPO_4$ (3 to 12 mg/L corresponding to a 3.1-12.5 fold increase) and soil type (i.e. increasing P solubilisation rates with decreasing soil P fixing status), indicating their selective effectiveness based on the type of inorganic phosphate and influenced by the soil's P fixing status.

These results confirm that specific strains of PSB can significantly enhance soil-available P in conditions that simulate natural soils. The developed methodology facilitates a systematic approach, from the initial screening of PSBs to their optimisation before large-scale nursery or field trials. This research may contribute towards the sustainable management of phosphorus fertilisation in oil palm cultivation, potentially lowering the ecological impact of phosphate utilisation.

(435 words)

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Modelling of carbon mineralization in earthworm casts using a descriptor of 3D structure changes

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Emission of carbon dioxide from soils participates to climate change actively. Earthworms, as the main ecosystem engineers, play an important role in this process by their impact on organic matter degradation and soil structure through cast formation. However, their impact on carbon mineralisation is poorly understood and has not yet been accounted for in organic matter (OM) models. In this study, we aimed to propose a simple mechanistic model of organic carbon mineralisation considering changes in cast structure during their long-term exposure to field conditions.

We used earthworms casts aged during different periods in agricultural fields under tropical conditions in Vietnam (0, 26, 72, 320 and 400 days). Incubations were carried out in laboratory during 80 days in order to measure carbon mineralisation (20 casts: 5 treatments x 4 replicates). Computed tomography (CT) images of the casts were analysed to obtain spatial parameters link to pore architecture and particulate organic matter (POM) distribution (image resolution of 10 µm). We developed a simple mechanistic model of carbon dynamic of the casts that account also for the spatial arrangements of POM and pores, implicitly.

The first step consists in providing a unique set of biological parameters able to simulate the carbon mineralisation of the 20 casts. In the second step, we optimized the structure factors for each cast, keeping the same set of biological parameters obtained in step 1. In the step 3, linear correlation were carried out to establish correlations between the 20 estimated structure parameters obtained in step 2 and the parameters calculated from CT images analysis of casts. We found that 9 CT parameters were necessary to simulate the estimated structure parameter accurately. Finally, in step 4, we simulated the carbon mineralisation of each cast using the unique set of biological parameters (step 1) and the calculated structure parameter (Step3). The parameter R2 of 0.82 indicated a good agreement between the simulated and the measured CO2 emission.

Our simple OM model was able to simulate the changes in carbon mineralisation accurately taking into account the spatial variability of POM and pore distribution in the casts.

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Tracing the bonding mechanisms of orgnano-mineral complexes behind formation of non-labile carbon pools in soil: implications for management

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Abstract

Organic matter and soil mineral surfaces can interact through an array of mechanisms to generate intricate bonds forming organo-mineral complexes that have considerable recalcitrance and play a significant role in stabilization of organic matter in soil. Soil management options play an variable role in influencing the bonding mechanism between organic matter and soil mineral surfaces and thereby influence organo-mineral complex formation vis-à-vis recalcitrance of soil organic matter. Stabilized soil organic matter can contribute to recalcitrant carbon pool and hence soil management options can play an important role in policy formulation towards carbon sequestration in soil. To test the hypothesis, we used soils from a long term experiment which received no fertilization, 100% N, 100% NPK, 150% NPK and 100%NPK+FYM (Farm yard manure) for the last fifty years. The experiment was conducted in a sub-humid region with soils being classified as Alfisol and dominated by Illitic clay mineral. The soils from the above mentioned treatments were sonicated and physically fractionated using nested sieves and the < 20 μm fraction was used in the study. It was observed that application of 100% NPK+FYM had the largest fraction of both total organic carbon (TOC) (0.95%) and non-labile carbon pool (40.53% of TOC) whereas unbalanced fertilization (100% N) had significantly lower TOC (0.53%) and non-labile carbon pool (19.06% of TOC). The micro-aggregate fraction (<53μm) corresponding to organo-mineral complexes, had the highest amount of associated C and N (0.86% and 0.66 g/kg, respectively) in 100% NPK+FYM treatment, whereas unbalanced fertilization (100% N) had far lesser values (0.61% and 0.46 g/kg

respectively). Examination of the bonding mechanism in the organo-mineral complexes this treatment revealed that most of the carbon (33.02%) was bound with strong linkages followed by carbon bound to sesquioxides (18.43%) and then by carbon bound through cation bridges (14.02%). This was followed by carbon strongly resistant to decompositon (13.70%), carbon weakly bound to minerals (11.38%). Carbon occluded in calcium carbonate was a meagre 9.02% and water soluble C or non-bound C was less than 1%. Whereas unbalanced fertilization (100% N) had most of the carbon as weakly bound (29.47%) followed by carbon bound with strong linkagse (26.54%). This was followed by sesquoxide bound carbon (14.26%) and then by calcium carbonate encapsulated carbon (11.08%), cation bound carbon (10.53%) and bonds strongly resistant to decomposition (7.29%). Water soluble carbon or soluble carbon was more than 1% in contrast to 100%NPK+FYM, which was <1%. The study highlights the importance of management options in stabilization of carbon in organo-mineral complexes with implications for policy formulation in terms of long term stabilization of carbon in soil.

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Microbial community variations according to using organic soil amendments for diseased organic turnip germplasm cultivation

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The cultivation of turnips, a cruciferous crop, is significantly challenged by clubroot disease, making its control difficult. This study was conducted to investigate the impact of materials used to control this biological limiting factor on the diversity of soil microorganisms. The effectiveness of five treatments, including soil amendments (eggshell calcium + carbonized rice husk), was evaluated on three landraces inoculated with clubroot disease. Soil samples were collected from each variety and treatment combination, and microbial growth was examined in various media such as KB, SDA, AIA, and TSA. The results showed significant differences in the composition and activity of microbial communities depending on the treatment. Following the application of carbon material-based organic farming materials and a mixture of antagonistic microorganisms (AFB2-2, GT-234), the microbial density in diseased soil increased by 38%p with the treatment of eggshell calcium + carbonized rice husk + antagonistic microorganisms, and decreased by 29%p with chitosan + antagonistic microorganisms, compared to the untreated control. These findings are crucial for understanding the impacts of clubroot disease control materials on soil microbial communities and for developing sustainable agricultural management strategies that take these effects into account.

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Effect of biochar combined with N–fertilizer on soil chemical and physical properties and N_2O emissions in Maize Crop

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Abstract

The global agriculture industry is facing issues such as soil degradation, water scarcity, rising greenhouse gas emissions, and climate change. Among the possible remedies, applying biochar to the soil has drawn interest as a viable strategy. Although a great deal of literature has been written about the benefits and drawbacks of applying biochar initially, there is still a gap in research on the effects of biochar re-application. This study seeks to address this gap by examining the varied effects of both the initial application in 2014 (at rates of 0 $t.ha^{-1}$, 10 $t.ha^{-1}$, and 20 $t.ha^{-1}$) and the reapplication of biochar in 2018 (at rates of 0, 10, and 20 $t.ha^{-1}$), especially when combined with different levels of nitrogen fertilizer (0, 108, and 162 $kg.ha^{-1}$) on soil chemical and physical properties and N_2O emissions during the growing season of maize in 2019. The results showed that biochar generally improved soil properties, such as soil pH (KCl) ($p < 0.05$), shifting it from acidic towards moderately acidic (increase in the range 7-13%), soil organic carbon —Corg (increase in range 2–21%), and generally led to a decrease in ammonium (NH_4^+) in range of 41–69%. Biochar increased slightly bulk density and soil water content and also positively influenced N_2O emissions from the soil (reduction in range 33–83%). Biochar did not have any effect on maize yield in 2019.There were more pronounced positive effects when biochar was re-applied.

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Assessing the Impact of Biochar Application on Soil Properties and Water Retention in Central European Agriculture: A Field Experiment

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Abstract

Recently, biochar has garnered scientific attention in agricultural research worldwide due to its favorable environmental impacts. To investigate the effects of biochar on soil organic carbon content, soil sorption, soil physical properties, and soil water retention, a field study was conducted in the temperate climate of Central Europe at the experimental field of the Slovak University of Agriculture in Nitra -Slovakia, with five experimental treatments: Control, Biochar 0, 10, and 20 t/ha, and nitrogen addition at a rate of 160 kg/ha (C, B10, B10+N160, B20, B20+N160)

Application of biochar with or without nitrogen fertilizer positively influenced soil water content in silty loam Haplic Luvisol during the maize growing season. Due to biochar application, soil moisture was significantly higher in all treatments during dry summer periods. Biochar, alone or combined with nitrogen, substantially increased soil porosity, relative aggregate stability, available water capacity, and soil water content. Additionally, biochar (with or without nitrogen fertilization) significantly reduced hydrolytic acidity and increased total soil organic carbon content. The addition of biochar led to complete saturation of the soil sorption complex, particularly with basic cations. Statistically significant linear relationships were observed between porosity and the sum of basic cations, cation exchange capacity, and base saturation.

Higher doses of applied biochar resulted in a more intense neutralizing effect on the soil.

Generally, the most pronounced changes in soil sorption parameters were observed after the application of biochar at a rate of 10 t/ha in combination with nitrogen fertilizer. In such cases, the soil sorption complex became fully saturated, and soil organic carbon content increased significantly. The most favorable effect on soil organic carbon content was observed after the application of 20 t/ha of biochar in combination with nitrogen fertilizer.

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Evaluating the potential utilization of Morgan extraction reagent for available sulfur in soils with various types of clay minerals

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Sulfur is an essential plant nutrient element that is mainly derived from soil organic matter and fertilizer, which is very effective for crop yield, and quality. Even if several extraction reagents have been proposed to analyze the available sulfur in soils, suitable extraction reagents for analyzing the available sulfur in soils across all types of clay minerals remain insufficient, particularly in Thailand. Therefore, the objective of this study was to compare two sulfate-S extraction methods for the extraction of available sulfur in soils with various types of clay minerals in Thailand. One hundred twenty-one soil samples were collected for this study based on their dominance of clay minerals, including 23 samples of red soils rich in kaolinitic clay minerals, 46 samples of mixed clay minerals, 12 samples of kaolinitic clay minerals, 18 samples of smectite clay minerals, and 22 samples of siliceous clay minerals. Available sulfur in all soil samples was extracted with two extraction methods, namely, the acetic-acetate method, in which the soil samples were shaken with an acetic-acetate reagent for 30 min as a control method, and the Morgan extraction method**,** in which the soil samples were shaken with a Morgan extraction reagent for 5 min. The extractable solution from both methods was subsequently determined by turbidimetry. A correlation analysis between these two methods was performed to test the potentiality of using the Morgan extraction reagent for extracting available sulfur in soils with different types of clay minerals. The results showed that positive correlations between available sulfur from both extraction solutions were observed for all soils with different clay mineral types. Their correlation coefficients were 0.996, 0.987, 0.875, 0.837, and 0.725 for mixed clay minerals, red soils rich in kaolinitic clay minerals, kaolinitic clay minerals, siliceous clay minerals, and smectite clay minerals, respectively ($P < 0.01$). These results suggest that the Morgan extraction reagent is applicable to be used for evaluating available sulfur in the soil, covering all types of clay minerals that are dominant in the soil with a more rapid analysis.

Evolution of microbial communities and soil functions on newly installed Rooftop Gardens

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Urban agriculture has been (re)developing all over the world over the last decade. The reasons for this trend range from leisure and economic reasons to a need for nature, and depend on the country in which it is practised. While cities are tending to encourage this practice, they are also coming up against the problem of lack of space, particularly in large megalopolises. As a result, rooftop gardens have been developed, necessitating the creation of soil, also known as Technosols. There are many questions about ecosystem services provided or the optimisation of these Technosols, which requires to look at how these highly anthropised soils function.

The aim of our project is to carry out a combined study of the quality of the soil, percolating water and biodiversity over time and as a function of three types of Technosols with varying levels of organic matter. Monitoring was carried out during the first year following the installation of these three Technosols on a green roof between May 2021 and May 2022 (3 replicates for each treatment).

We will concentrate here on the study of soil micro-organisms and their relationship with the mineralisation of organic matter and structural stability. C and N mineralisation and structural stability were assessed in the laboratory using soil samples taken at the start and end of the experiment, and on each horizon. Microbial communities (abundance and diversity) were analysed every two months.

Rapid dynamics in the microbial communities were observed during the first year of installation of the Technosols and will be related to the functions measured.

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Microbial processing and mineral filtering define the composition and fate of mineral-associated organic matter in soil

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Formation of mineral-associated organic matter (MAOM) supports accumulation and stabilization of carbon in soil, and thus, is a key factor in the global carbon cycle. Yet, the processes driving the formation of MAOM are not completely understood. One open question is what determines the nature and composition of the organic matter (OM) that becomes associated with minerals. We expected that mineral type is the major determinant of the composition MAOM, but that mineral filtering for specific compounds is modified by vegetation, i.e. input of different OM, and microbial processing. We addressed this research question by exposing mineral containers with pristine minerals (goethite, as a representative of oxide-type mineral phases, and illite, representing layered aluminosilicate minerals) for five years to ambient soil conditions in 27 grassland and 27 forest plots in three pedo-geological different regions across Germany. After recovery, the contents of organic carbon (OC) and total nitrogen (TN) of the field-exposed minerals were determined by dry combustion. In addition, the samples were analysed for ^{13}C abundance as indicator of potential sources (microbial vs. plant-derived) of the newly formed MAOM. The nature of OC accumulated on the mineral surfaces was analysed using X-ray photoelectron spectroscopy (XPS), providing information on carbon oxidation states. To gain insight into the relationship between the composition of MAOM and its stability, results of the XPS analysis were compared to the mineralisability of MAOM-C (i.e., the amount of CO_2 released per gram MAOM-C during incubation under standard laboratory conditions). We found stronger accumulation of OM on goethite than on illite, which went along with stronger accumulation of highly oxidized carboxylic carbon on goethite. The role of carboxylic functional groups underlines the importance of partial microbial oxidation of OM in the formation of MAOM. The mineral filtering for carboxyl functional groups also appears to be a factor in the observed smaller mineralisability of goethite than illite MAOM-C. The higher mineralisability of illite MAOM-C corresponded with higher ^{13}C abundances on illite than goethite samples. The findings suggest preferential accumulation of more microbial residues on illite due to the higher availability of illite MAOM. Land use type, i.e. vegetation, had little effects on the shares of oxidized carbon, but the increased ^{13}C abundances on both minerals suggested larger contributions of microbial residues to newly formed MAOM under grasslands. Overall, the results suggest that the formation and stability of MAOM are driven by the interplay of microbial oxidation of the OM entering the soil and subsequent binding of oxidized degradation products by minerals, which prevents complete oxidation.

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Characterization of pore networks at an aggregate scale in Andosol and Acrisol using synchrotron-based X-ray micro-computed tomography

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Abstract

Soil aggregates are the clusters of soil particles adhered more strongly relative to the rest of the soil solid matrix. Aggregates thus provide habitats for soil microorganisms and unique micro-environments for various biogeochemical reactions. In particular, the aggregate pore network is an important feature closely linked to soil functions. Non-destructive characterization of pore network of intact soil structure is becoming possible at the spatial scale relevant to microbial process understanding using the X-ray micro-computed tomography (µCT) technique. However, we still have a limited understanding of how soil type, soil mineralogy, and potential binding agents for aggregation affect the pore networks. Andisols are known to have very low bulk density (ca 0.5-0.9 g cm-3, thus high porosity) and contain larger amounts of potential binding agents (short-range-order aluminosilicate called allophane/imogolite as well as organo-metal complexes) compared to other, more weathered soil types. We thus hypothesized that, even at a macroaggregate scale, Andisols have higher porosity and more open pore networks.

Two soil types common in Japanese cropland were selected for this test: an allophanic Andosol (45% clay, Ibaraki, Japan) and an Acrisol (38% clay, Shizuoka, Japan). We collected bulk soil samples from a tilled layer (Ap horizon) for both soil types. Using the field-moist samples, water-stable macroaggregates with a diameter of 5-7 mm were obtained by wet sieving and air-dried. X-ray µCT analysis was conducted on these macroaggregates at BL20B2 of the SPring-8 (energy: 30.0 keV, pixel size: 2.72 µm/voxel, imaging mode: offset).

We are currently analyzing the X-ray µCT data to characterize the pore networks (pore, open/closed pore, and pore size distribution) of these aggregates by Amira 3D (Thermo Fisher Scientific, US). We will examine (i) to what extent, the high porosity (low bulk density) observed at the field (bulk soil) scale is reflected at the macroaggregate scale, (ii) what are the origins of the high porosity (pore size classes, inner vs. outer zones of aggregates), and (iii) if the aggregates of the Acrisol abundant in phyllosilicate clays have more packed structure with limited pore network, and discuss possible implications for microbial processes at the aggregate scale.

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Factors controlling carbon concentrations in global Andisols: a meta-analysis

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Abstract here

Increasing evidence suggests that storage and persistence of soil organic carbon (SOC) are controlled by the contents of reactive metal phases, such as organically-complexed aluminum (Al) and iron (Fe) and short-range-order (SRO) minerals, in soil at local and regional scales. Yet the global significance of the metal-SOC relationship and the specific metal phases controlling SOC storage remain unclear due to the high variation in geological parent materials and rock-climate-SOC interactions. Andisol is the soil type developed from the most homogenous parent material (volcanoclastic materials), characterized by high contents of SOC and reactive metal phases, and thus ideal to examine the metal-SOC relationships that would develop during soil formation under varying environmental conditions. We synthesize a global Andisol database from over 2850 soil samples across 34 countries, covering a wide range of mean annual temperature (−2–30 °C), precipitation (60–6000 mm/y), and soil pH (3.1–9.3). Generalized additive mixed model analyses showed the first direct evidence that, among the reactive metal phases, organically-complexed Al (pyrophosphate-extractable Al, $\mathrm{Al_p}$) was the strongest predictor of SOC concentrations after accounting for soil depth at the global scale. SRO aluminosilicate (acid oxalate-extractable Al minus $\mathrm{Al_p}$) showed a moderate importance whereas reactive Fe phases showed minor explanatory power. Clay content had little contribution whereas exchangeable calcium showed its importance at higher pH. Stronger $\mathrm{Al_p}$-SOC relationship found in more developed (andic) relative to younger (vitric) Andisols implies that the interaction of organic compounds with pedogenic Al released via weathering may continue to play a critical role on SOC storage over prolonged time, which is consistent with the SOC-metal correlations reported in other meta-analyses that cover most soil types. Together, our study strongly suggests that reactive Al phases contribute more directly to SOC storage than Fe phases or clay content at the global scale.

Seasonal pattern of soil microorganisms abundance and activities in a landslides affected zone under restoration

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Understanding how natural disasters affect soil quality and how it recovers is essential to improve soil management. Here we studied a landslide affected grassland in a steppic biogeographical region, Romania (Hamcearca, Braila). Restoration is performed with *Onobrychis viciifolia* and *Cynodon dactylon*. The study was performed on bulk soil and rhizosphere soil in fall and spring period (2023 – 2024). Soil microbiota phenotypic structure and abundance was performed applying phospholipids derived fatty acid methyl esters approach (PLFA). The microbial activities were analysed through different fluorescent enzymatic assays involved in carbon (C), nitrogen (N), and phosphorous (P) cycles. In this study the soil microbiome phenotypic structure presented a bacterial dominance (F/B ~ 0.2). Between bacterial communities, more abundant were the Gram-negative and anaerobe bacteria phenotypic groups with and average abundance of ~ 70 and 20 $\text{nmol} \cdot \text{g}^{-1}$ d.w. soil. Although no significant differences were observed between microbial phenotypic structure and abundance in bulk and rhizosphere soils, the opposite was measured for studied extracellular enzymatic activities (EEAs). Here lower EEAs was measured in bulk soils compared with rhizosphere ($p < 0.05$). C cycle related EEA were lower with approximately 36 % in bulk soil. No significant differences were observed for EEAs involved in N and P cycles. This could be attributed probably to the *Onobrychis viciifolia*, as this plant is recognized a contributor in N and P fixation. These findings of this present study may provide a scientific and practical reference for the control and improvement of landslides affected grasslands.

Landslide affected grassland, Hamcearca (Braila), Romania

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Land use impact on soil metabolite profile in calcareous chernozems soil, Limanu, Pontic area

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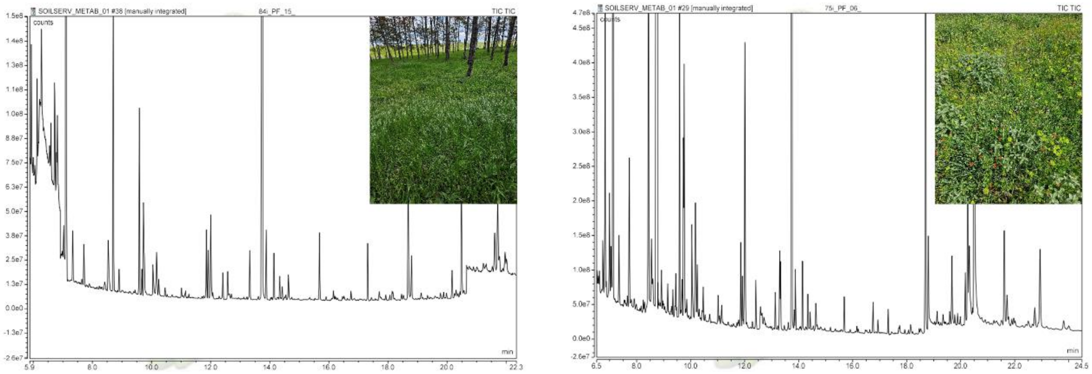
Soils support a wide range of ecosystem services that ensure the functioning of the Earth system. Impacts of land use on the soil system could disrupt the delivery of these services. It is therefore essential to establish robust approaches to assess how soil ecosystem quality is affected. Here, we studied how a grassland and a *Pinus nigra* forest (Limanu, Pontic biogeographical region) induce changes in a calcareous chernozems soil property. The two land uses were located in immediate proximities. Soil properties was studied in its term of physicochemical, biochemical and biological properties. Biological properties referred at soil microbiome phenotypic structure and abundance while the biochemical properties to the soil metabolites profile. Soil microbiome was assessed applying phospholipids derived fatty acid methyl esters approach (PLFA, GC-FID). Soil metabolites profiles were identified applying gas-chromatographic mass spectrometric (GC-MS/MS) approach on derivatized and non-derivatized soil extracts. According to our study the microbial abundance was greater in forest than in grassland with approximately 25 %. However, the metabolites profile was richer in grassland soil than in that of *Pinus nigra* forest soils. In grassland soils were identified an average of 162 metabolite compounds while in forest soils were identified an average of 87 metabolite compounds. Main identified metabolites belong to lipids, amino acids, organic acids, carbohydrates and volatile organic compounds. This study results highlight that soil metabolites profile could offer significant information about the impact of land use on the complex molecular network and metabolic pathways operating soil microorganisms-plant community.



Soil metabolites change with land use (Limanu, Romania)

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Dynamics of dissolved organic matter in buried black layers of volcanic ash soil

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It is well known that Japanese volcanic ash soils often contain buried black A horizons with significantly high carbon content, including biochar. However, the dynamics of dissolved organic matter (DOM) in these soils are not well understood, especially in comparison to the brown B horizon found at similar depths. The purpose of this study is to elucidate the DOM dynamics in the buried black soil layer of volcanic ash soils. To clarify the quantity and quality of DOM sorbed onto buried black soil layers of volcanic ash soils, DOM eluted from two representative deep soils (buried black soil (2A) and brown clay soil (Bw)) at the Takayama site in Gifu Prefecture, Japan, were analyzed by the following two methods. (1) SUVA method and (2) Excitation-Emission Matrix and parallel factor analysis (EEM- PARAFAC analysis).

Test soils, while maintaining field moisture content (pF = 1.8), were sieved to less than 2 mm and preincubated at 25°C for 1 week. The DOM material was dried and powdered *Miscanthus sinensis*. 0.25 g of it was mixed with 2 L of water in a polyethylene bottle. The bottle was shaken 10 times and allowed to stand for 5 minutes, which was repeated three times. Subsequently, the bottle was left in a cool, dark place for 24 hours and filtered by suction through a 0.3 µm glass fiber filter paper. 40g of soil, on a dry soil basis prior to incubation, was packed in a plastic container with small holes in the bottom, and 120 ml of DOM was dripped into the container at a rate of 4 ml per minute. Liquid from a small hole at the bottom of the container was suction filtered through 0.3 µm glass fiber filter paper and treated as DOM eluted from the soil. DOM was measured as A_{254}, DOC concentration, and EEM, and A_{254} was divided by DOC concentration to obtain SUVA; EEM-PARAFAC modeling was composed of 970 samples of forest soil leachate and nearby system runoff.

The A_{254} of DOM eluted by soil infiltration decreased to less than 20% of the A_{254} of 2A before the experiment and was significantly lower than the A_{254} of Bw, suggesting that infiltration of DOM causes the buried black soil to selectively adsorb highly aromatic organic matter. EEM-PARAFAC analysis showed that DOM eluting from 2A had significantly fewer fluorescent components (humic substances (humic acids, fulvic acids, etc.) and non-humic substances (proteins, etc.)) than Bw. This indicates that 2A adsorbs a greater variety of DOM components than Bw. This study demonstrates that buried black soils in volcanic ash soils have the ability to adsorb a wide variety of organic matter, especially persistent organic matter.

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Cryoconite as a model of soil aggregation in extreme environments: interactions between minerals, organic matter and microorganisms on ice

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Cryoconite – a dark-colored, well-aggregated, and C-rich fine material on ice (Takeuchi et al., 2001, 2003, 2010) might have been present on glaciers throughout their history on Earth. During massive cooling periods from the Proterozoic up to the late Pleistocene, when subaerial surfaces largely turned into supraglacial, cryoconite might have been a widespread and crucial unit for interactions between minerals, organic matter (OM), and microorganisms. It continues to support these functions in the modern "melting world" of retreating glaciers. Cryoconite granules are widely represented on the ablation surfaces of glaciers worldwide. They support complex organomineral interactions, concentrate OM of both local (photoautotrophic) and external origins. Eventually, C-rich cryoconites contribute to the depauperate soils of the freshly exposed periglacial environments. Here we explore the hypothesis that principles of aggregation in cryoconite are similar to those manifested in soil aggregates and that cryoconite granules can be used as a model to study organomineral interactions and subsequent aggregates formation in extreme environments, e.g., on ice and in periglacial settings. For this purpose, we employed SEM-EDS (including MAPS mineralogy), X-ray computed microtomography (μCT), Raman and FTIR microspectroscopy, ^{14}C dating, measured concentrations of C and N, and studied their stable isotope ratios in various cryoconites from glaciers of the mountain and polar regions (Svalbard, Caucasus, Altay and others). Cryoconite granules consistently had a total porosity within 15-20% with a high proportion of interconnected pores (>80%). Phyllosilicates, such as smectite, kaolinite, chlorite, and micas, played a significant role in maintaining the physical stability of granules. The periphery of granules had multilayered structures (8-50 layers) and included the greatest amounts of silty-clay particles (>30%) running parallel to the outer surface of granules. Phyllosilicate clusters were interlayered with amorphous C-rich cement that originated from the extracellular polymers (EPS). Methyl functional groups were confined to the outer walls of granules, suggesting their hydrophobic properties, that are crucial to support the stability of aggregate in meltwater and promote attachment of microorganisms. The outer shell of granules composed of OM-clay associations played a key role in maintaining stability of the inner core of the aggregate and provided favorable conditions for OM transformations *in situ*. We identified the following mechanisms of physical and chemical stabilization of cryoconite granules, reminiscent of those known for microaggregates in soils: 1) occlusion/encapsulation; 2) formation of multilayered concentric structures (granules/ooids); 3) adsorption on active mineral surfaces, e.g., clays (clay-EPS associations); 4) hydrophilic-hydrophobic interactions; 5) accumulation of polyaromatic C compounds. This work has been supported by RSF project No. 20-17-00212.

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Mineral-organo matter interactions in permafrost and their sensitivity to priming

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Understanding organo-mineral interactions in permafrost is paramount to predicting the climate change feedback potential of the vast amount of carbon stored in the warming Arctic. As organic matter (OM) becomes accessible to microbes in thawing permafrost, positive priming—stimulating OM decomposition via root exudates— can occur. However, the extent of OM losses upon permafrost thaw will be influenced by mineralogy and its protective role against warming and positive priming. This study aimed to 1) characterize organo-mineral interactions and soil organic carbon content in active layer and permafrost soil along a landscape age gradient and 2) determine how differences in organo-mineral interactions affect the fate of simulated root exudates and the vulnerability of native soil organic matter (SOM) to priming in active layer and thawed permafrost soils.

Active layer and permafrost soils were collected from the North Slope, Alaska, USA from four sites of different landscape age. We performed sodium pyrophosphate, ammonium oxalate, and citrate dithionite selective dissolutions to test Al and Fe mineral phases stabilizing OM. Fifty-six jars were incubated at 5 °C under oxic conditions for 12 weeks, with a continuous ^{13}C-labeled exudate cocktail and corresponding controls to test the effect of root exudates on priming. We measured the amount and isotopic enrichment (^{13}C/^{12}C) of CO_2 in the jar headspace weekly. Preliminary results showed that the site with the least soil development had the highest soil carbon concentrations prior to incubation. As landscape age increased, we observed decreasing pH and iron activity ratios which are indicative of increased weathering. Active layers generally contained fewer poorly crystalline Fe and Al minerals compared to permafrost. We hypothesize this is the result of state changes in Fe mineral phases caused by varying redox conditions in the active layer-permafrost transition zone, influenced by hydromorphic processes. Incubation data showed that the SOM in permafrost is more vulnerable to priming than OM in the active layer. Across sites, the addition of new OM led to a negative priming effect in mineral active layers and only caused positive priming of OM in permafrost from the oldest site. Our initial findings highlight the need to better understand the vulnerability of permafrost C to decomposition, coupled with changes in mineral sorption capacity, microbial communities and fresh OM inputs.

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Deciphering the relative importance of active Al and active Fe as controlling factors of soil organic C in tropical paddy soils

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In tropical acidic soils, soil organic carbon (SOC) content is more closely correlated with the content of active and/or organically-bound aluminium (Al) and iron (Fe) than with clay and silt contents. However, active Al and Fe are often considered collectively, leading to ongoing debates regarding the preferential control of SOC by either Al or Fe in soils. Thus, our objective was to quantitatively assess the relationship between SOC and active Al and Fe, focusing on their relative predominance in tropical acidic soils.

We analyzed 306 surface soil samples (0–15 cm depth) collected from paddy fields in the central highlands of Madagascar. SOC was quantified using the dry combustion method with an NC analyzer. Soil pH was determined in deionized water at a soil-to-solution ratio of 1:5. Extractable Al and Fe contents were determined using the acidic ammonium oxalate method (Alox and Feox, respectively). We defined soils with the molar ratio of Alox to Alox + Feox exceeding 0.5 as Al-dominant soils and the others as Fe-dominant soils. The number of Al-dominant soils and Fe-dominant soils were158 and 148, respectively.

Soil pH was mostly acidic, with a mean value of 5.3, and was negatively correlated with SOC across all soils ($r = -0.26$, $p < 0.001$). No significant correlation was found between Alox and Feox across all soils ($p = 0.42$). SOC varied from 24.2 cmol kg^{-1} to 1115.1 cmol kg^{-1} with a mean value of 241.4 cmol kg^{-1}. Alox + Feox exhibited a linear relationship with SOC ($R^2 = 0.77$, $p < 0.001$) across all soils. In the Al-dominant soils, SOC was linearly correlated with Alox ($R^2 = 0.68$, $p < 0.001$) but not with Feox (Fig. 1a). In the Fe-dominant soils, SOC was more closely correlated with Feox ($R^2 = 0.39$, $p < 0.001$) than with Alox ($R^2 = 0.27$, $p < 0.001$) (Fig. 1b). These results indicate that SOC in tropical paddy soils is primarily controlled by either active Al or active Fe depending on their predominance.

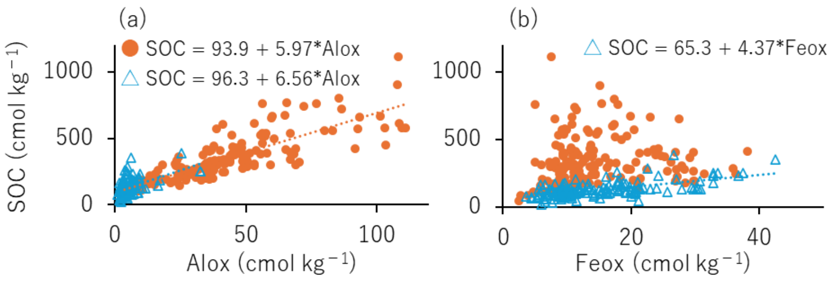

Fig. 1 Relationship between SOC and Alox (a) and Feox (b) in Al-dominant (●) and Fe-dominant (△) soils.

Distribution of microbial metabolic power in the soil pore network

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Soil microbial communities live within a complex three dimensional pore network, the properties of which constrain microbial activity. The physical structure of the pore network limits microbial access to resources. It also affects the micro-environmental conditions (e.g. redox conditions, pH) that can affect microbial use of the available resources and the rates at which they use energy. Whilst the distributions of different types of activities (CO_2 production, enzyme activities) in the pore network have received some attention, the rate at which microbial communities use the energy available to them, i.e. metabolic power, has not been studied in any great detail. However, energy is required for most aspects of microbial functioning and the rate at which this energy is used determines the extent to microbial activity and growth proceed.

Linking the energy available to the rate at which it is processed at the pore scale may help us to better understand how microbial growth and C dynamics are constrained by the physical environment in soil. In order to do so, we added isotopically-labelled organic substrate to pores with different neck diameters and measured microbial catabolic rates and the associated Gibbs energies of the reactions. This allowed us to estimate the distribution of microbial metabolic power in the pore network and of carbon use efficiency. We then compared the distributions of metabolic power with those of carbon use efficiency at the pore scale.

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Export of soil organic carbon from iron-rich polar peatlands to aquatic ecosystems: Insights from molecular spectroscopy and chromatography

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Abstract

Large amounts of organic carbon (OC) are currently stored in northern peatlands (~500 Pg),[1] wherein 25% of this OC stabilized by its interaction with iron minerals.[2] However, with continuing global warming, soil OC loss through vertical fluxes (i.e. CO_2, CH_4) have been studied, especially in thawing permafrost soils.[4,5] Meanwhile, lateral carbon fluxes,[3] such as mobility of soil OC in the presence of iron colloids from soils to rivers, is not well understood; yet, determining the role of Fe-OC flocs in the shifting carbon and iron biogeochemical cycles in polar ecosystems will be crucial in a future fast warming climate.

To address this knowledge gap, we followed the changes in Fe-OC flocs from an Fe-rich peatland (source) in Iceland,[6] as they are transported through a 30-km peat-draining river to the Atlantic. Our Fe K-edge X-ray absorption spectroscopy (XAS) and infrared (IR) analyses revealed that the Fe-OC flocs are made up of short-ranged ordered Fe-nanophases having molecular signatures indicative of microbial-derived OC moieties. We evaluated how OC speciation in flocs and water is affected during transition from peat soils, to freshwater, and ultimately to brackish waters. Using C K-edge µ-XAS on the Fe-OC flocs, we show that as these flocs are transported along the river, aromatic OC become enriched, while aliphatic OC were quickly depleted upon export. Using size exclusion chromatography (SEC), we document the (bio)degradation of peat-released humic-like OC along the river transect. Our new molecular insights into the key biogeochemical processes in such polar peatland-river ecosystems revealed (i) what controls Fe-OC floc formation in polar peatlands, (ii) how OC transport and speciation change along the transition from terrestrial to coastal ecosystems, and (iii) what their potential contribution to delivery of nutrients to Arctic oceans is.

References: (1) Hugelius et al., *PNAS* **2020**, *117* (34), 20438. (2) Lalonde et al., *Nature* **2012**, *483* (7388), 198-200. (3) Battin et al., *Nature* **2023**, *613* (7944), 449-459. (4) Herndon et al., *Geochim. Cosmochim. Acta* **2017**, *207*, 210-231. (5) Patzner et al., *Nat. Commun.* **2020**, *11* (1), 6329. (6) Linke et al., *Geochim. Cosmochim. Acta* **2024**, *370*, 66-77.

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Mineral-associated organic matter in carbon-rich African Dark Earth soils: Implications for Carbon Saturation Theory

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Mineral association is a dominant mechanism that contributes to SOM persistence, but there is active debate about whether soil minerals have a finite capacity to sorb organic carbon (OC) and no consensus on how to quantify a theorized upper limit of mineral-associated organic matter (i.e., C saturation capacity). African Dark Earth (AfDE) soils have been heavily amended over hundreds of years, creating a darkening of the natural soil due to large amounts of OC compared to unamended adjacent soil (AS), and thus represent a potential end-member model system of maximized SOM persistence. We characterized organo-mineral associations in AfDE and AS in eleven paired soil profiles from Liberia and Ghana by determining soil C loadings before and after uncomplexed organic matter removal by density and size fractionations. C loading values (mg C m^{-2} soil) were calculated from specific surface area (SSA) and soil organic C (SOC) concentrations to quantify the degree of mineral C saturation and thus the degree to which mineral association contributes to persistence. We compared soil C loadings to a hypothesized theoretical soil C saturation threshold (1 mg C m^{-2} soil), and compared bulk soil C loading to heavy density and fine size fraction C loadings to determine the degree to which bulk C-loading values were affected by the presence of uncomplexed OM. Mean C loading in bulk AS (0.89 mg C m^{-2} soil) was below, and mean C loading in bulk AfDE (2.3 mg C m^{-2} soil) was substantially above 1 mg C m^{-2} soil. After removing uncomplexed organic matter, AS heavy fraction C loading (0.97 mg C m^{-2} fraction) and AS fine fraction C loading (1.1 mg C m^{-2} fraction) remained below but close to the theoretical threshold, and AfDE heavy fraction C loading (1.9 mg C m^{-2} fraction) and AfDE fine fraction C loading (2.4 mg C m^{-2} fraction) were lower than bulk soil values but remained above the threshold. The presence of char and the amount of MAOM in African Dark Earths suggest free or mineral-associated carbon-rich material such as pyrogenic C (i.e., char) could increase soil C saturation capacity beyond what would normally be anticipated for highly weathered tropical soils considering their relatively small mineral SSA. The impact of fine particulate char and mineral-associated pyrogenic C on soil C saturation capacity, and therefore soil C stabilization, should be explored further because with improved climate-smart management practices, particularly biochar amendment, global tropical soil C sequestration potential may exceed current estimates.

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Relationship between contents of sclerotia of *Cenococcum* species and soil organic matter fractions in low pH forest soils

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Sclerotia of *Cenococcum* species tend to be particularly abundant near *Cenococcum* mycorrhiza, as spherical grains of 0.05 to 4 mm or more in diameter. According to previous studies, the ^{14}C ages of sclerotia from surface A and buried A horizons of beech forest soil were approximately 100 to 200 years B.P. and approximately 300 to 1,200 years B.P., respectively, and the ^{14}C ages of sclerotia were older than those of humic acids. Based on this fact, sclerotia were considered to persist for a long term as a structural organic component in soils. In this study, we obtained quantitative information on the relationship between sclerotia content and soil organic matter fractions. Sclerotia were directly separated from surface soils by wet sieving and hand sorting methods. The analysis of soil organic matter fractions followed previous studies, with sieving performed at 53 micrometers. Gravity fractionation was conducted for larger fractions, while oxidation decomposition using sodium hypochlorite solution was carried out for smaller fractions, evaluating the carbon contents of the four fractions. The formation of sclerotia would be regulated by soil physicochemical properties and microbial activities. Simultaneously, sclerotia in soil are exposed to the decomposition process. Sclerotial C in surface soil showed the potential to be equivalent to microbial C. C reserved as sclerotia of *Cenococcum* species may contribute as relatively hard-decomposed C and enlarge the mean residence time of C as a soil organic component in subalpine forest soil. Furthermore, the formation of sclerotia may play important roles in the humification process.

Title: **Impact of Iron Forms on Phosphate and Organic Carbon in permafrost-thawing Alpine Wetlands of Eastern Pamir, Tajikistan**

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Abstract: Our research investigates the biogeochemical interactions between organically bound iron and essential plant nutrients in alpine wetlands, particularly under conditions resulting from melting permafrost. In particular, we investigated how non-silicate iron contributes to the release of phosphorus, a key nutrient for plant growth in low-oxygen environments. This process, driven by Fe(III)-reducing bacteria, not only liberates iron and carbon but is also intensified by the thawing of permafrost, potentially increasing carbon mobilization due to the destabilization of iron(III) minerals. Our research, conducted in high-altitude wetlands in the eastern Pamir Mountains, Tajikistan, uses a spatial approach to assess correlations between different forms of non-silicate iron, total organic carbon (TOC), and phosphate under different moisture conditions and soil types. We conducted comprehensive analyses on stratified peat/mineral soil profiles, evaluating key parameters including humidity, pH, total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), carbonates and phosphate levels, as well as isotope ratios ($\delta^{15}N$, $\delta^{13}C$). For iron speciation—distinguishing between free iron (Fe_{free}), organically bound iron (Fe_{org}), and total iron (Fe_{tot})—we employed the citrate-dithionite method in conjunction with aqua regia. Our research showed a significant difference in total and free iron content between soil types ($P<0.0001$), with mineral soils containing a much more significant amount of it than organic soils. Moreover, no correlation was found between free iron (Fe_{free}) and organically bound iron (Fe_{org}) in peat profiles, while such a relationship was visible in mineral soil profiles. Our findings indicate a direct correlation between soil chemistry as total organic carbon (TOC) increases, soil pH decreases (r = -0.4***), and phosphate levels rise (r = 0.4**), while carbonate content decreases. The correlation analysis reveals that total iron content exhibits a positive relationship with carbonates (r = 0.3*) and a negative relationship with phosphates (r = -0.2*). Free iron negatively correlates with humidity (r = -0.4**), TOC (r = 0.3*), and phosphates (r = -0.4**), while organically bound iron shows a positive correlation only with TN content (r=0.4**). These variations in total (Fe_{tot}) and free iron ($Fe_{\_free}$) levels are likely due to permafrost thaw-induced changes in wetland hydrology, especially evident in ombric-humic-cryic Histosols near lakes. Additionally, a marked decrease in carbon isotope ratios (δ13C) with depth in these peat deposits highlights the significant impact of permafrost and groundwater interactions on carbon sources. This research was funded by the Polish National Science Centre, Grant Nos. 2013/09/B/ST10/01662 and 2017/25/B/ST10/00468.

Addition of pulverized lignite accelerates bioconversion of chemically solubilized lignite to methane by a methanogenic consortium

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Lignite is an underutilized natural resource with limited commercial circulation due to its low calorific value. However, its effective conversion into methane holds significant promise in addressing the global energy crisis. This study reports the successful bioconversion of organic matter from chemically solubilized lignite into methane using a methanogenic consortium, specifically a mixed methanogenic enrichment culture (mMEC).

In our microcosm experiments using the mMEC, we observed the onset of methane production within seven days. Moreover, the methane yield increased with the total organic carbon concentration of the solubilized lignite solution. Notably, methane production was dramatically enhanced—by approximately 50-fold—when pulverized lignite was added as a solid phase to the microcosms. Quantitative real-time PCR analysis revealed significant increases in the copy numbers of 16S rRNA and *mcrA* genes, with 13-fold and 20-fold increases, respectively, in microcosms with pulverized lignite compared to controls without it.

These results suggest that pulverized lignite serve as a solid surface conducive to biofilm formation, fostering the growth of archaea and bacteria and thereby boosting methane production. To the best of our knowledge, this study reports the highest recorded increase in methane production relative to control groups. Our findings demonstrate that adding pulverized lignite as a solid phase can significantly enhance the bioconversion of chemically solubilized lignite solution into methane, offering a promising strategy for leveraging this abundant yet underexploited, resource for energy production.

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Parent Material Influences SOM-Mineral Association Patterns in O layers of Forest Soils. A close look into the role of Calcium

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Abstract

In forest ecosystems, the accumulation of plant residues on the surface layers of the forest floor (FF) creates a unique zone rich in soil organic matter (SOM) which provides essential ecological services such as nutrient, water, and carbon storage that are crucial for forest vitality and productivity. The susceptibility of SOM to mineralization is strongly affected by the extent of organo-mineral associations and assemblages. Recent studies show that organic layers of FF can contain considerable amounts of mineral compounds attributed to different pathways such as bioturbation, atmospheric particle deposition, precipitation of secondary minerals, among other processes. Parent material plays a crucial role in defining soil mineralogy and nutrient supply through weathering processes; depending on the type (calcareous or silicate), contrasting mineralogies emerge as well as different bonding mechanisms and interactions with SOM, influencing SOC stabilization to varying degrees. The effect of parent material on temperate forests has been well recognized in the top and subsoil, but not its influence on organo-mineral associations in organic layers. Within the framework of the DFG-funded Research Unit "Forest Floor" (RU 5315), we aim to fill this gap by investigating the effects of parent material (basalt, paragneiss, dolomite, limestone) on the type and extent of mineral-associated SOM, its influence on SOC concentrations, SOM forms, and SOM quality (C:N:P:S). Furthermore, we are particularly interested in unveiling the role of calcium in forest floor SOC/SOM binding patterns. To accomplish this, we studied the organic layer and top mineral soils of 20 sites of temperate mixed forests (*Fagus sylvatica* dominated) across Germany and Switzerland. The application of a density fractionation method adapted to the forest floor allowed us to discriminate SOM moieties differing in composition, OC concentration, chemistry (Al, Fe, Ca, Mg), and degree of SOM-mineral interactions. We identified different contributions of OC species to SOM with the application of ^{13} C NMR spectroscopy. By using X-ray Absorption Near-Edge Structure (XANES) at the Ca K-edge, we detected contrasting Ca species bound to inorganic (e.g., lithogenic, clay) and organic (e.g., oxalate) constituents in different proportions, changing across parent material-derived soils and within organic layers and mineral horizons. Our research brings new knowledge about SOM-mineral association in organic layers of FF shaped by parent materials. We also contribute important insights into the possible mechanisms involved in the formation and turnover of FF, as well as the resistance of SOM to microbial decomposition.

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Disentangling sources and contributions of particulate and mineral associated organic carbon to SOC in topsoil and subsoil in temperate acidic forests of Japan

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Soil organic carbon (SOC) represents the largest carbon pool in terrestrial ecosystems and can be physically categorized into three fractions: unprotected particulate organic carbon (fPOC), particulate organic carbon occluded within aggregates (oPOC) and organic carbon associated with minerals (MAOC). Based on the C/N ratio, fPOC has the highest value and originates from uncomplexed plant detritus, while oPOC and MAOC consist of aggregations of less processed structural inputs and dissolved organic carbon sorbed onto mineral surfaces. Topsoil and subsoil in forests differ in their sources of organic inputs, as well as the size of each SOC fraction. However, there is limited research comparing the origin of each fraction and its contribution to SOC between soil horizons. Therefore, this study aims to 1) Distinguish the sources of SOC fractions based on plant/microbe-derived compounds and 2) Clarify the difference in contributions of POC and MAOC to SOC in top- and subsoil.

Samples (n = 28) were collected from topsoil and subsoil in acidic forests (pH < 6). Samples were fractionated into three pools based on density (1.6 g cm $^{-3}$) and size (53 µm). Soil C and N content in both bulk and fractionated soils were determined using dry-combustion. One-shot pyrolysis was applied to determine the molecular compounds in SOC.

SOC was 156 and 34 g C kg $^{-1}$ in top- and subsoil, respectively. The fPOC/N was highest among SOC fractions in both top- (22) and subsoil (35). Compared to topsoil with symbolistic compounds derived from plants (i.e. lignocellulose), fPOC in subsoil was positively correlated with short- and long-chain alkanes (r_s = 0.58* and 0.63*), potentially derived from leaching. The mean values of oPOC/N and MAOC/N were higher than 15 in topsoil, exceeding the ranges of C/N ratios postulated for microbes, indicating a plant source for both fractions. In subsoil, their mean values became lower (oPOC/N:9, MAOC/N:11). oPOC was positively correlated with N-containing compounds (r_s = 0.74**), suggesting the aggregation potentially formed by microbial products, such as proteins. The positive correlation between MAOC with phenols (r_s = 0.76**) provided evidence for vertical movement of plant-derived compounds from topsoil. Based on path analysis, oPOC significantly contributed to SOC in topsoil (R^2 = 0.71, β = 0.84***) while in subsoil, SOC was well explained (R^2 = 0.94) by significant contributions from both oPOC (β = 0.69**) and MAOC (β = 0.62***). There was no significant contribution from fPOC in either topsoil or subsoil.

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Environmental and management controls of soil carbon storage in grasslands of southwestern China

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In order to predict the effects of climate change on the global carbon cycle, it is crucial to understand the environmental factors that affect soil carbon storage in grasslands. In the present study, we attempted to explain the relationships between the distribution of soil carbon storage with climate, soil types, soil properties and topographical factors across different types of grasslands with different grazing regimes. We measured soil organic carbon in 92 locations at different soil depth increments, from 0 to 100 cm in southwestern China. Among soil types, brown earth soils (Luvisols) had the highest carbon storage with 19.5±2.5 kg m^{-2} while chernozem soils had the lowest with 6.8 ±1.2 kg m^{-2}. Mean annual temperature and precipitation, exerted a significant, but, contrasting effects on soil carbon storage. Soil carbon storage increased as mean annual temperature decreased and as mean annual precipitation increased. Across different grassland types, the mean carbon storage for the top 100 cm varied from 7.6±1.3 kg m^{-2} for temperate desert to 17.3±2.9 kg m^{-2} for alpine meadow. Grazing/cutting regimes significantly affected soil carbon storage with lowest value (7.9±1.5 kg m^{-2}) recorded for cutting grass, while seasonal (11.4±1.3 kg m^{-2}) and year-long (12.2±1.9 kg m^{-2}) grazing increased carbon storage. The highest carbon storage was found in the completely ungrazed areas (16.7±2.9 kg m^{-2}). Climatic factors, along with soil types and topographical factors, controlled soil carbon density along a soil depth in grasslands. Environmental factors alone explained about 60% of the total variation in soil carbon storage. The actual depth-wise distribution of soil carbon contents was significantly influenced by the grazing intensity and topographical factors. Overall, policy-makers should focus on reducing the grazing intensity and land conversion for the sustainable management of grasslands and C sequestration.

Whole-soil warming effects on soil carbon cycling in an alpine grassland

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The impact of warming on the carbon cycling of terrestrial ecosystems can determine the carbon cycle-climate change feedback and the future climate. How warming affects the carbon cycling in deep soils (>30 cm) remains uncertain, because most of existing manipulation experiments only warm surface soils (<30 cm). In 2018, we started a Total-soil-warming Experiment in an Alpine Meadow (TEAM) on the Tibetan Plateau, where we have maintained year-round warming (+4 oC) of the whole soil profile (0-100 cm. I will present an overview and some of the results of TEAM during the first 6 years (2018-2023), including treatment effects on plant communities, soil and microbial properties, and ecosystem processes.

First, warming did not significantly affect plant richness and diversity, and above- and belowground biomass and productivity, but changed the relative proportion of plant functional groups in aboveground biomass (decrease in legumes and increase in forbs). Second, soil physico-chemical properties (including organic carbon and total nitrogen concentrations) and microbial community characteristics (such as carbon use efficiency, community diversity and composition) throughout the profile were mostly unresponsive to warming, although they changed dramatically (e.g. declined) with depth. Third, warming significantly stimulated soil respiration (and microbial respiration) and soil N_2O emission, but did not significantly change root respiration and soil CH_4 uptake. Lastly, warming promoted plant growth, soil microbial respiration, and soil fauna feeding activity by 8%, 57%, and 20%, respectively, but caused dissimilar changes in their phenology during the growing season. Overall, although ecosystem carbon stocks were not significantly affected by the whole-soil-warming, some processes and variables of the alpine grassland ecosystem showed significant responses. We will continue to monitor these processes and variables to gain a long-term mechanistic understanding of the response of ecosystem carbon cycling to whole-soil-warming in the alpine grassland.

Session 4:

ISMOM and biogeochemical cycling across scales

Changes in particulate and mineral-associated organic matter and microbial biomass in apple orchard soils under elevated temperature and CO_2 concentration conditions over four years

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To determine the effects of global warming on soil organic matter, changes in particulate and mineral-associated organic matter and microbial biomass in apple orchard soils under elevated temperature and CO_2 concentration conditions were analyzed. Soil samples (0-10 cm) were collected from three experimental plots established at the Hirosaki University farm over four years from 2019 to 2022. The experimental plots were a control plot with only a roof, a high-temperature (HT) plot in an enclosed greenhouse with a temperature 3°C higher than the outside air, and a high-temperature/high-CO_2 (HT/HC) plot in an enclosed greenhouse with a temperature 3°C higher than the outside air and a CO_2 concentration 200 ppm higher than the outside air. In each plot, 16 apple trees were grown under sod culture. The soil samples were fractionated into particulate organic matter (POM, >53 µm) and mineral-associated organic matter (MAOM, <53 µm) fractions by sieving after mechanical dispersion, and the total carbon and total nitrogen contents of the soils and fractions were determined. Soil total carbon content decreased significantly from May 2019 to September 2020 in all plots, with greater decreases in the HT and HT/HC plots than in the control plot, indicating that elevated temperatures promoted organic matter decomposition. Changes in the carbon content of the POM and MAOM fractions indicated that the decrease in soil organic matter during this period was mainly due to a decrease in POM. From September 2020 to September 2022, the soil total carbon content continued to decrease in the control plot, while it remained unchanged in the HT plot and slightly increased in the HT/HC plot. During this period, a slight increase in POM was observed in the HT and HT/HC plots and MAOM increased only in the HT/HC plot. Infrared absorption spectrum measurements showed an accumulation of organic matter with a low degree of decomposition in the MAOM fraction, especially in the HT/HC plot, in September 2022. These results suggested that the supply of plant-derived organic matter increased after the second year in the HT and HT/HC plots. The total dry matter production of apple trees and undergrowth was HT/HC > HT > control in all years, and increased with each passing year in all plots, confirming the increased supply of plant-derived organic matter in the HT and HT/HC plots. Changes in microbial biomass, an indicator of readily decomposable organic matter, supported that elevated temperature increased the supply of plant-derived organic matter and that elevated CO_2 concentration further increased the supply. In conclusion, it is predicted that soil organic matter will not decrease in apple orchards in the short term if global warming progresses due to rising atmospheric CO_2 concentration.

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Mechanisms affecting the fate of biochar and compost mixtures in agricultural soil from temperate climate.

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Joint field application of biochar and compost has been suggested as a promising strategy to improve soil organic carbon (SOC) storage, soil quality and crop production. However, little attention has been paid to the mechanisms controlling the residence time of these materials after joint application to temperate agricultural soils. Aim of the study was to investigate the possible biochar-compost interactions to affect the fate of both materials during 2 years of field exposure. *Miscanthus* biochar and green-waste compost were placed mixed or separately in litterbags containing soil from agricultural field in temperate climate. A combined particle size water fractionation and water densimetric separation allowed to separate free particulate organic matter (POM) fractions from water stable soil aggregates, at different sizes: 4-2 mm, 2-0.2 mm, 0.2-0.005 mm and < 0.005 mm. We used elemental analysis and stable isotope labelling at natural abundance to follow the fate of organic carbon (OC) from compost and biochar in the mixtures from the free POM fractions.

OC from biochar and compost mostly accumulated in the free POM fraction, evidencing no strong interaction with the soil minerals after 2 years on field. The biochar free POM fractions were redistributed from the 4-2 mm to the 2-0.2 mm and 0.2-0.05 mm size fractions, while no similar redistribution was observed for the compost free POM fractions. Isotopic analysis revealed that the biochar free POM fractions were less redistributed when mixed with compost than when added as pure component, suggesting that biochar-compost interactions may reduce the physical disintegration of the biochar free POM fractions. We conclude that although not significantly interacting with the soil minerals in the first 2 years on field, biochar and compost may interact together on ageing mechanisms, thereby affecting the C storage potential of biochar in soil.

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Fertilizer application of the digestate after a two-stage, hydrogen, and methane-yielding AD process - influence on activity of nitrogen-fixing bacteria

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Organic fertilizers can be derived from many different wastes and by-products including a digestate-specific effluent simultaneously produced with biogas during the anaerobic digestion (AD) process. Biogas production is possible thanks to the interactions of many groups of microorganisms. In conventional applications (biogas plants – one-stage AD), all these microorganisms are kept together in a single reactor system. However, processing organic compounds in two separate reactors can enhance AD process. Besides the increased stability, two-stage AD provides the combined production of H_2 (stage 1) and CH_4 (stage 2). Managing of digestate from a two-stage, H_2-CH_4-yielding AD process represents a significant challenge and is an extremely little-known issue. Nevertheless, our research team believes that utilizing this digestate as a fertilizer can be a way to create advantageous organic soil additives that affect soil chemistry and microbiology to increase soil fertility.

Nitrogen fixation is the second most important biogeochemical process after photosynthesis. Nitrogen-fixing soil bacteria supply a significant amount of the mineral nitrogen used in agriculture providing an ecologically acceptable complement for N fertilizers. All nitrogen-fixers carry a nifH gene, which encodes the Fe protein of the nitrogenase.

This study aimed to evaluate the effects of fertilization with digestate from a two-stage AD process that yields H_2 and CH_4 on the expression of the nifH gene.

In pot experiments, wheat was cultivated in nutrient-poor sandy soil. The doses of digestate used as a fertilizer were determined by taking into account the permissible amount of nitrogen. Experiments were carried out with relevant controls - without any fertilizers, with synthetic fertilization, and with one-stage digestate fertilization. RNA was isolated from the soil using a commercially available extraction kit. cDNA synthesized on the extracted RNA template was subjected to digital PCR (dPCR) analysis. Amplification of the nifH gene was done using the PolF and PolR primers.

In the results, the copy number (cp) of the nifH gene per gram of soil significantly differs across the experimental variants. The lowest cp was observed for the synthetically fertilized variant, followed by the unfertilized variant. One-stage digestate fertilization significantly increased the cp of nifH gene. Nevertheless, the highest cp was observed for fertilization with digestate from a two-stage, H_2-CH_4 yielding AD process. In summary, it can be concluded that digestate obtained as a result of the two-stage process stimulates the activity of nitrogen-fixing bacteria boosting the natural fertility of the soil.

References:

1. Chojnacka, A., Błaszczyk, M.K., et al. „Comparative analysis of hydrogen-producing bacterial biofilms and granular sludge formed in continuous cultures of fermentative bacteria.” Bioresource Technology, 102 (2011) 10057-10064.
2. Chojnacka, A., Szczęsny, P., et al. „Noteworthy facts about a methane-producing microbial community processing acidic effluent from sugar beet molasses fermentation.” Plos One, 10 (2015) e0128008.
3. Barros, R., Martins, F., et al. "Spatial and seasonal responses of diazotrophs and ammonium-oxidizing bacteria to legume-based silvopastoral systems." Applied Soil Ecology 158 (2021): 103797.
4. Thauer, Rudolf K., et al. "Methanogenic archaea: ecologically relevant differences in energy conservation." Nature Reviews Microbiology 6.8 (2008): 579-591.

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Bacterial microbiome in the soil from areas cultivating two cassava cultivars demonstrated functions that promote plant growth and contribute to the carbon cycle

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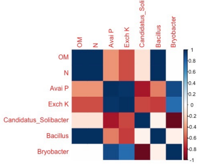
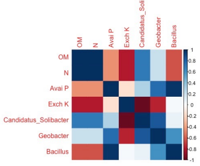
Metagenomics had revealed the functions of soil bacteria in the soil from areas cultivating two cassava cultivars and their association with the carbon cycle. The experiment aimed to investigate the bacterial microbiome and explore their relationship with soil properties. DNA was extracted from three replicates across two treatments: T1: soil from areas cultivating the Rayong72 cultivar (SCW), and T2: soil from areas cultivating the Hanatee cultivar (SCV). The DNA was amplified using the 16S rRNA (V3-V4) gene, illumina sequencing, followed by metagenomic analysis and microbiome correlation with soil properties was analyzed. In SCW, the most abundant bacteria belonged to three phyla: Acidobacteria (41.29%), Proteobacteria (22.21%), and Firmicutes (7.52%). The top three families were identified unidentified_Solibacterales (5.62%), Burkholderiaceae (5.19%), and Bacillaceae (3.23%). At the genus level, the most prevalent were Candidatus_Solibacter (3.23%), Bacillus (3.23%), and Bryobacter (2.31%). Conversely, in SCV, the dominant phyla were Acidobacteria (32.79%), Proteobacteria (30.59%), and Bacteroidetes (6.56%), with top three families being unidentified Solibacterales (6.73%), Burkholderiaceae (5.38%), and Prolixibacteraceae (3.67%). The genera were *Candidatus_Solibacter* (4.23%), *Geobacter* (2.52%), and *Bacillus* (2.47%). The Shannon-Weaver diversity indices were high, at 8.90 for SCW and 9.32 for SCV. Genera such as *Geobacter*, *Candidatus_Nitrosotalea*, Haliangium, *Reyranella*, and *Dongia* were more abundant in SCV than in SCW. In contrast, *Candidatus_Nitrososphaera*, *Paenibacillus*, and *Tumebacillus* showed higher abundance in SCW than in SCV. Organic matter and nitrogen demonstrated a strong positive correlation with *Bacillus* spp. in SCW, whereas available phosphorus correlated positively with *Bacillus* spp. in SCV. Thus, many bacteria exhibited roles in promoting plant growth through nitrogen fixation, phosphate solubilization, and phytohormone production, while others contributed to the carbon cycle through hydrolytic enzyme production for organic carbon breakdown, secretion of extracellular polymeric substances, and pathways of soil greenhouse gas emissions.



SCW



SCV

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No-tillage practice reduces organic matter decomposition and its dependence on temperature in soil

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No-tillage practice is one of the potential strategies to increase storage of soil organic matter (SOM) under a warming climate. However, the effects of tillage on soil C stocks are variable and inconsistent across global temperature regimes, because decomposition of native SOM and net accumulation of newly added substrates respond differently to temperature. Land use change chronosequence and isotope tracing allow us to test whether tillage practices affect decomposition and accumulation properties. We compiled data on turnover of SOM under no-tillage and conventional practices to calculate decomposition rate constants in the first-order kinetics and their dependence on temperature. We found that no-tillage practice reduces decomposition rate constants of SOM by 37% ± 8% (mean ± S.E.). Decomposition of the native SOM increased with temperature both under no-tillage and conventional practices, but SOM decomposition under no-tillage responds less sensitively to temperature. Net accumulation of newly added C is less sensitive to temperature and it increases with increasing clay content. The SOM preservation by no-tillage practice is effective in tropics and clayey soils.

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Effects of decadal soil managements on the nature of OC in mineral-associated organic matter in temperate arable soils: the role of reactive minerals

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Climate-smart agricultural management (CSA) including organic fertilization and crop rotations has been promoted to enhance organic carbon (OC) storage in arable soils largely via manipulating organic matter (OM) input to soils. However, it remains unclear if CSA can increase C in mineral-associated OM (MAOM) which is important for long-term C storage. Also, CSA would potentially affect organo-metal associations in MAOM by changing, for example, soil pH or the input of base cations (e.g. Calcium (Ca^{2+})). This study thus aims to examine the extent to which long-term (> 20 yrs) CSA enhances C in MAOM as well as in particulate organic matter (POM) compared to inorganic fertilization (control) in arable topsoils under temperate climate. Specifically, we tested if long-term CSA management affected OC pools within MAOM fraction (e.g. OC bound to metals extracted from reactive minerals).

Using the soils from eight sites under contrasting soil mineralogy (i.e. Andisol and non-Andisol) from Japan, Canada and France, we conducted density fractionation (cut-off density: 1.8 g cm^{-3}) with sonication (475 J mL^{-1}) to isolate POM and MAOM fractions and measured C and N contents in these fractions. Additionally, to analyse organo-metal associations in MAOM, we extracted aluminium (Al), iron (Fe), Ca and metal-bound OC from MAOM fraction by pyrophosphate (PP) at pH 10 and dithionite-pyrophosphate (PD) at pH 7.5. Using sodium hypochlorite oxidation technique, we also measured oxidation-resistant C content, which is known to be a stable OC pool compared to bulk MAOM-C. For data analysis, a whole dataset was grouped into Andisol (n = 3 sites) and non-Andisol (n = 5 sites). To assess CSA effects on OC fractions and extractable metals in comparison with control, we calculated a response ratio for these properties (e.g. a ratio of MAOM-C in CSA to that in control) in each soil group. If a ratio was significantly larger than one, a given variable was interpreted to be effectively enhanced by CSA management.

We found that POM-C was effectively enhanced by CSA managements for both soil groups, whereas CSA effectively enhanced MAOM only for non-Andisoil group. Among C pools in MAOM of the non-Andisol, oxidation-resistant C, which contributed 20±8 SD % of MAOM-C fraction, was also increased by CSA but to a smaller extent than in bulk MAOM, while PD-extractable metal-bound OC, which contributed 20±7 SD % of MAOM-C, was not enhanced

significantly by CSA. Regarding the management effects on extractable metals in MAOM, PP- and PD-extractable Al and Fe (defined as metals in organo-metal complexes and those in presumably “total” reactive minerals, respectively) were not affected by CSA, whereas this management significantly increased PP-extractable Ca compared with control. These results indicate that (i) CSA is beneficial for increasing long-term C storage in MAOM fraction including oxidation-resistant C of the non-Andisol group and (ii) the formation of additional MAOM-C may be mediated by increased extractable Ca content. For the Andisol group, parts of POM-C may be stabilised by reactive mineral phases, which will be discussed in this presentation.

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Impact of Long-Term Cattle Stocking Rates on Grassland Carbon Sequestration, Carbon Fractions and Soil Microbiome

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Abstract

This research project aims to explore the relationship between cattle stocking rates and carbon sequestration in grassland soils for a period of over 80 years. Given the global urgency to mitigate climate change, understanding the capacity of agricultural practices to influence carbon dynamics is crucial. This study provides a comprehensive analysis of how varying cattle densities affect soil carbon stocks, potentially offering insights into sustainable livestock management and its environmental benefits.

In 1942, the South Dakota State University's Cottonwood Research Station near Philip, SD, USA designated six pastures to three levels of grazing intensity—low, moderate, and high. These pastures have been continually stocked with cattle during the growing season from June through August each year to sustain these conditions. Over time, this consistent grazing strategy has led to the formation of three distinct types of plant communities within the rangeland. These range from diverse vegetation in lightly grazed areas, featuring a mix of warm and cool season grasses, to areas dominated by shortgrass, such as buffalograss and blue grama, in heavily grazed sections. These pastures have been maintained with minimal changes in management other than variations in cattle stocking rates, providing a unique long-term perspective on grazing impacts.

From each stocking density, soil cores were collected at different depths (0-7.5, 7.5-15, 15-30, 30-60 and 60-100 cm) and transects (shoulder-, back- and toeslopes) to measure total carbon, organic carbon, and inorganic carbon levels. Additionally, corresponding analysis of carbon fractionation (both particulate organic matter (POM) and mineral-associated organic matter (MAOM)), CO_2 respiration and soil microbiome community structure were assessed to gauge potential microbial activity and carbon cycling. Preliminary results indicate that despite vegetation changes based on grazing intensity, stocking rates had a far smaller effect on soil organic carbon and/or soil carbon fractions as compared to soil texture and landscape position.

The implications of this study are significant for environmental policy and sustainable agriculture. While cattle stocking rate is a critical component of sustainable grazing lands, the implications for carbon sequestration and soil health will be dependent on where these practices are implemented. For example, as sand content increases and specific surface area decreases, less carbon is retained, regardless of grazing treatment.

These findings advocate for integrated livestock management strategies that target implementation based on geographical distribution, which accounts for underlying geologic processes. Overall, this research underscores the potential of managed grazing systems to serve as viable, yet nuanced solutions for carbon sequestration in the fight against climate change. These solutions also include aspects of sampling design, power statistics and stratification to align soil carbon assessment, monitoring, and reporting efforts.

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VNIR hyperspectral imaging for soil organic matter research: mapping the subsoil C spatial heterogeneity in contrasting biogeochemical domains

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Subsoils generally have lower concentrations of organic matter and nutrients, and are a place with less biological activity when compared to topsoils. On the other hand, due to their large volume, they can store significant amounts of water, and of soil organic carbon and nutrients. For these reasons they are getting increasing attention, especially in agroecosystems where enhanced subsoil utilization by deep-rooting crop cultivars is seen as an option to support soil fertility and crop water availability during drought.

The Bonares - Soil^3 project aims at investigating the potential of subsoil management for agriculture. In the frame of this project, we collected samples from several field experiments in Germany, and investigated the potential benefits of subsoil loosening, together with deep placement of organic fertilizers on agricultural productivity and soil organic matter stocks.
We quantified the changes in C and N stocks and we also recorded hyperspectral images of 1-meter soil cores in the visible-near infrared range (186 bands: 400-990 nm) to model the C distribution at a high spatial resolution (pixel size = 53×53 µm²) using machine-learning algorithms.
The organic matter stocks and C:N stoichiometry are both changed by the direct deposition of organic fertilizers in the upper subsoil, but we did not detect significant effect of the management at most soil depths.
The imaging technique allows us to resolve the subsoil spatial heterogeneity and to distinguish between increased amount of organic carbon in localized hotspots (deep-root channels, metal oxides, clay accumulation) or in the more homogeneous soil mineral matrix, and to discuss the mechanisms controlling the observed changes. The spatial resolution we can obtain with VNIR hyperspectral imaging, with detailed obtained at sub-millemetric scale for whole one-meter deep soil cores, allows for the accounting (size and numbers) at the field level of these fine-scale organization of soil domains with contrasting biogeochemical reactivity, and of their response to the agricultural subsoil management.

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Long-term convergence of amino acid compositions commonly observed in terrestrial and marine organic matter degradation

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Decomposed organic matter, including soil organic matter, constitutes a significant portion of the carbon reservoir on Earth's surface and is considered important for carbon sequestration due to its long turnover time. Notably, soil organic matter is known to have a longer turnover time than most biogenic, refractory organic matter. What underlies this persistence? This study focuses on the amino acid constituents of decomposing organic matter. Amino groups and amide structures are relatively commonly observed even in well-decomposed organic matter. Thus, amino acids in decomposed organic matter may shed light on the refractory nature of decomposing organic matter. We aggregated data on the amino acid profiles of organic matter across various decomposition stages in both soil and marine environments, probing for systematic alterations in amino acid composition throughout decomposition. The results indicate that the amino acid composition of degraded organic matter is not particularly close to that of microorganisms. Moreover, the changes in the amino acid composition of the decomposed organic matter were found to be consistent, with an increase in the proportion of glycine and a decrease in the proportions of leucine and phenylalanine. These results suggest that specific amino acid molecules are involved in the remaining decomposed organic components. These amino acid changes were common to both terrestrial and marine decomposition, suggesting that they are universal and independent of the environment.

Nitrate-reducing bacterial community analysis of a *Miscanthus condensatus* rhizosphere on the acidic volcanic ash deposits of Miyake-jima, Japan

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The ecosystem at the summit of Mt. Oyama on Miyake-jima become disrupted due to a huge eruption in 2000, which resulted in the accumulation of volcanic ash and the release of acidic volcanic gases. Our previous study showed that chemoautotrophic bacterial community has been identified as the predominant microbe because volcanic ash deposits within 10 years contain less carbon and nitrogen and a low pH. After 21 years from the eruption, an increase in organic matter in volcanic ash deposits accompanied by pioneer plant, *Miscanthus condensatus* overgrew, and then the microbial community structure shifted to heterotrophic bacterial community. In our previous result, microbial metagenomic analysis in the *M. condensatus rhizosphere*, which grow on volcanic ash deposits, suggested competition for the utilization of nitrate nitrogen. In this study, we identified bacteria accompanying with nitrate-reducing activity from the *M. condensatus* rhizosphere to elucidate the utilizing nitrate as a substrate in the acidic volcanic ash deposits. We obtained bacterial isolates from the rhizosphere soil of *M. condensatus* collected at site OY at 23.8 year. Molecular phylogenetic analysis based on 16S rRNA gene sequencing was carried out and showed taxonomic diversity; 15 isolates containing *Alphaproteobacteria* (*Bradyrhizobium* and *Mesorhizobium*), *Betaproteobacteria* (*Caballeronia*, *Paraburkholderia*, *Ralstonia*, *Collimonas*, three isolates of *Duganella*, two isolates of *Rugamonas*, and *Roseateles*), and *Gammaproteobacteria* (*Pantoea* and two isolates of *Pseudomonas*). Additionally, nitrate-reducing abilities by potential denitrification and dissimilatory nitrate reduction to ammonium (DNRA) were verified 13 isolates and 3 isolates, respectively. According to the *M. condensatus* rhizosphere soil DNA metagenomic data of site OY at 21.1 year, the relative abundance of the *nirB*, *nirD*, *nirK*, and *nirS* genes involved in nitrate reduction were showed considerably higher than that of nitrogen oxidation. In addition, we found *nirB*, *nirK*, and *nirS* of the genus *Bradyrhizobium*, *nirB* of the genus *Caballeronia*, *nirK* of the genus *Paraburkholderia*, and *nirD* of the genus *Pseudomonas* from the metagenomic data. To the best of our knowledge, this is the first study to obtain nitrate-reducing bacterial isolates that correspond with the functional genes identified in the metagenomic data from the rhizosphere of *M. condensatus* grown on Miyake-jima volcanic ash deposits.

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Fractionation of soil organic carbon affected by different croppings in northern Taiwan

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Total organic carbon is not equivalent to the long-term stability of carbon storage in soil. To know more about soil organic carbon (SOC) partition, different SOC fractions can be isolated according to physical and chemical schemes for better understanding of SOC pool. This study used different management approaches with arable land use such as upland cropping with fountain grass (*Pennisetum alopecuroides*) under different fertilizer treatments (manure, manure + nitrification inhibitor, manure + chemical fertilizer, chemical fertilizer + nitrification inhibitor, and chemical fertilizer) and paddy rice with different water management (rainfed and conventional irrigation) in northern Taiwan. Soil samples are regularly collected (0-20 cm) for the fractionation of SOC. The soil sample was firstly separated into sand, silt + clay fractions. Then the sand fraction was divided into the light fraction (LF) ($< 1.8\ g/cm^3$) and heavy fraction (HF) ($> 1.8\ g/cm^3$) using the sodium polytungstate. The fraction including silt and clay was further treated by NaClO. Further, the residues were classified as non-oxidizable fraction (NOxF) and the others were oxidizable fraction (OxF). The aggregate stability, organic carbon functional groups by FT-IR and NMR, and microbial activity are also performed for these soil samples. The experimental results showed that the quality of soil organic carbon is affected by different fertilization treatments, because the light fraction was significantly highest (2.43-4.06 g/kg) under the upland treated with manure + nitrification inhibitor, while the heavy fraction was notably highest under manure + chemical fertilizer treatment (1.28-3.24 g/kg). The oxidizable and the non-oxidizable fractions of SOC were consistent in all fertilizer treatment of upland. Under rainfed management, all fractions of SOC in the paddy field were significantly ($P < 0.05$) higher than those in the upland. Additionally, the manure application increased the soil aggregate stability. In paddy field, the soil aggregate size became small under conventional irrigation, which aggravated the decomposition of SOC. Based on the spectra of FT-IR and NMR, the treatment of manure + chemical fertilizer facilitated more conversion and accumulation of Alkyl C, suggesting advanced decomposition stages of plant residues in the upland. However, rainfed treatment of paddy field enhanced Alkyl C/O-alkyl C ratio, supporting the increase of SOC humification, in comparison with conventional irrigation. We recommend employing manure for upland and rainfed management for paddy field to preserve the SOC quality and enhance the stable forms of SOC.

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Title: Quantifying the Organo-Mineral Soil Architecture via image meta-analysis of NanoSIMS measurements

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The interface of soil organic matter (OM) and minerals provides hotspots for various biogeochemical processes, forming the basis of carbon storage, microbial habitats, and exchange sites of plant nutrients. Analytical advances of spectromicroscopic techniques, such as nano-scale secondary ion mass spectrometry (NanoSIMS) have provided insights into the complex arrangement of different organic and mineral soil functional components at the microscale. However, an overarching approach quantifying the organo-mineral micro-architecture has been hindered by the lack of data mining approaches. By using a machine-learning based image processing, we were able to integrate a large dataset based on NanoSIMS. Here we present various quantification approaches to describe the spatial arrangement of soil organic matter and minerals, such as the OM coverage, connectivity, interface length and composition, as well as the co-localization or neighbouring with major specific mineral phases. These quantified spatial patterns of organo-mineral interactions can be related to soil properties, such as OM content and composition, or the experimental C/N ratio that may interrelate with and the local normalized N/C ratio. Our approach aims to provide a general understanding of organo-mineral architecture at biologically relevant scale and how the microscale arrangement is linked with physicochemical properties. Further, we will explore how the organo-mineral architecture forms functional regions that may locally drive biogeochemical processes.

Relationship between organic carbon and mineral nutrients and diversity and structure of microbial communities in biological soil crusts in contrasting deserts: cold desert of Pamir, Tajikistan and hot deserts of California, USA.

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Biological soil crusts (BSC) are important communities of microorganisms in arid and semi-arid environments, inhabiting surface microlayer of soil. Cyanobacteria play in these communities' crucial role in carbon and nitrogen sequestration. Even not diazotrophic cyanobacteria thanks to production of EPS and organic exudates may influence nitrogen sequestration forming cyanosphere which attracts other, also the diazotrophic, bacteria.

We performed our study in two types of deserts: cold, mountainous desert of Eastern Pamir, Tajikistan and hot desert of California with one bordering sample from Nevada, USA. We sampled biological soil crusts collecting 26 and 21 samples respectively and analyzed the environmental parameters (*in situ* and in laboratory) as well as performed metagenomic barcoding of the whole bacterial community with special attention given to cyanobacteria.

Our study revealed that the structure of bacterial community at the phylum level was similar in both contrasting environments. Pseudomonadota, Cyanobacteria, Becteroidota and Actinomycetota formed the core bacterial phyla in both deserts' types. As regards Cyanobacteria we observed larger differences with prevalence of Nodosilineace and Nostocaceae in cold desert and increased contribution of Chroococcidiopsidaceae and Coleofasciculaceae in hot desert. In both regions comparable percentage of potentially N_2 fixing cyanobacteria occurred though they were represented by different orders. In California, the hot desert with lower averaged precipitation, bacteria correlated positively with total N, total C, Mg, Na, K, Ca, $CaCO_3$ and EC, while cyanobacteria exhibited opposite tendencies both at the phylum level as well as at most of the families. In cold desert of Pamir however, the relationships were much weaker, less clear, and variable within the families. Phormidesmiaceae exhibited positive relationship with total carbon and total Ca and $CaCO_3$, while Limnotrichaceae correlated with salinity, Na, TN and Mg.

Fast decomposition of nitrogen-rich mineral associated organic matter in soils

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Mineral-associated organic matter (MAOM) is considered a stable reservoir for soil nutrients, accounting for the majority of soil carbon (C) and nitrogen (N) in mineral soils. However, the mechanisms of stabilization and the decomposition of MAOM are not well understood. It is generally believed that N-rich compounds in soils have a higher affinity for adsorption to mineral surfaces than nutrient-free organic compounds. Therefore, C covalently bound to N may have a longer residence time than C of nutrient-free compounds. In this study, we incubated ^{13}C-labelled microbial- and plant-derived MAOM with varying clay mineral compositions in three different sets of incubation experiments: 1) mixed with four different soils (2 forest and 2 grassland soils), 2) microbial-derived MAOM with three C concentration gradients, and 3) sterilized and non-sterilized of microbial-derived MAOM, to obtain varied N compounds of MAOM. Contrary to expectations, we found that the decomposition of microbial-derived MAOM-C enriched in N compounds was higher than that of plant-derived MAOM-C, and the decomposition of MAOM-C was positively correlated with the proportion of N compounds. These results challenge the widely held assumption that N-rich compounds can be firmly bound to minerals and decomposed slowly. Our finding that high decomposition of microbial-derived MAOM-C also suggests that traditionally reported turnover time of MAOM-C based on radiocarbon dating may be overestimated.

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Effects of rice-straw incorporation and tillage on soil carbon stability and greenhouse gase emissions in alternate wetting and drying managment of paddy soils

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Abstract

Rice cultivation significantly contributes to global methane (CH4) emissions due to continuous submergence in paddy soils. To address this issue, innovative agricultural practices such as alternate wetting and drying (AWD) irrigation have been proposed by organizations like the International Rice Research Institute (IRRI). AWD helps mitigate methane emissions by, but its impact on soil carbon stability and nitrous oxide (N2O) emissions remains controversial. Moreover, the abundance of rice straw presents a post-harvest waste management problem, but also provide a potential strategy for enhancing soil organic carbon levels, potentially aiding carbon sequestration. However, the implications of rice straw incorporation management on soil carbon stability and greenhouse gas emissions, particularly N2O, are still debated. This study conducted a field experiment in completely blocked plots (15*50m) at Ankang Experimental Farm, National Taiwan University. The treatments included: (1) no rice straw return and no tillage, (2) rice straw return with tillage, (3) rice straw return without tillage. Soil greenhouse gas emissions were continuously monitored with a multichannel automated chamber system equipped with trace gas analyzers throughout the paddy rice cutivation. Additionaly, soil samples before and after rice cultivation were collected for the analysis of soil carbon fractionation and aggregate stability. The result shows that returning rice straw to the field reduces N_2O emissions during drainage periods and intermittently between consecutive rice cultivations, while soil carbon content and aggregate stability were enhanced after rice cultivation. The results of the present study provides information to elucidate the underlying mechanisms of carbon turnover and N_2O emission in response to alternate wetting and drying water management, regarding the dynamics C-N cycle.

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Soil Organic Matter and Carbon Sequestration: Insights from Combustion Elemental Analysis and Temperature Gradient Method applied for biochar analysis

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In the quest for sustainable solutions to mitigate climate change, the role of soil organic matter (SOM) and carbon sequestration has emerged as an area of scientific interest. Among the techniques available for soil analysis, combustion elemental analysis and the relatively new temperature gradient method to distinguish total organic carbon (TOC400), total inorganic carbon (TIC900) and residual oxidizable carbon (ROC) stand out as indispensable tools, offering insights into the dynamics of SOM and carbon sequestration mechanisms.

Using elemental analysis, we analyze the composition of biochar, which defines its potential as a carbon sink and soil amendment agent. Employing the temperature gradient method, we differentiate the carbon pools within soil samples, including TOC400, TIC900, and ROC, helping to elucidate the mechanisms underlying carbon sequestration processes.

In this talk we will give an insight into the functionality, advantages and challenges of the temperature gradient method and present data from different sample matrices together with CHNS/O analysis of biochar and other samples relevant for carbon sequestration.

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Reconstructed soil profiles utilizing excess mineral material – a strategy of improving soil fertility after moving soil?

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Expansion of larger cities and building of a new infrastructure generate pressure on the valuable agricultural areas. In Norway, only 3% of total land is arable. Often, these limited productive areas in Norway are sacrificed for big infrastructure projects due to natural, hilly landscape, and to limit cost in expensive infrastructure projects. Moving productive soil and reconstructing a new soil profile at a new location can be an alternative strategy limiting the loss of arable land. At the same time, global mining industries accumulate excess waste mineral materials that may be suitable for agriculture usage and construction of so called Technosols as they often contain valuable macro and micronutrients for plants. When reconstructing a soil profile at a new location, there is a potential opportunity to improve the fertility of the original B horizon by adding these mineral byproducts. While crushed rock has been tested as lime and fertilizer added to the topsoil A-layer, little is known about potential short and longer-term effects of combining the original B layer soil with selected excess mineral materials.

As part of a larger study focusing on soil movement and design of soil B-horizions utilizing waste rock material as a soil additive to improve soil health, soil profiles were constructed in columns in laboratory. A soil column leaching experiment was established and ran for 8 months. The constructed soil profiles consisted of a 5 cm deep A horizon overlying a 15 cm deep B horizon. The B horizons were amended with four different excess mineral materials, i.e., carbonatite, greywacke, gabbro, and clayey shale. The columns were regularly filled with water, and collected leachates were analyzed for pH, dissolved organic – and inorganic carbon (DOC, DIC), plant macro and micronutrients and potentially hazardous trace elements. The chemical and mineralogical composition of the mineral materials were evaluated prior to execution of the above-mentioned experiments, by polarized microscopy, X-Ray Fluorescence (XRF), X-Ray Diffractions (XRD) and Scanning Electron Microscopy Based Automated Mineralogy (SEM-AM). The specific surface area of the mineral particles was measured by the Brunauer-Emmett-Teller (BET) method by nitrogen adsorption. After 8 month the experiment was terminated and the soils were analyzed for pH, cation exchange capacity (CEC) and base saturation (BS%). Preliminary results from the column leaching experiment showed that the addition of mineral material had a liming effect, by increasing the pH from 5.8 (day 0) to 8.4. The pH stabilized at the higher level during the experiment. Addition of the excess waste rocks increased the concentration of the essential plant nutrients Ca, K, Mg, Cu and Mo.

Influence of Soil and Landscape Properties on Orchard Soil Microbiomes and Heterotrophic Respiration in Central Chile

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In agricultural systems, heterotrophic soil respiration, a key process in carbon cycling, can be influenced by soil microbiomes. In turn, the soil microbiome is modulated by both soil properties and the landscape characteristics of the surrounding area. This study aims to explore how the interaction between soil microbiomes and their surrounding native vegetation—specifically shrubland and forests—affects soil respiratory processes in orchards across Central Chile (a spillover effect). We hypothesized that greater similarity in soil biogeochemical properties between orchards and adjacent natural environments would lead to a more similar microbiome, potentially modulating heterotrophic respiration. Our research involved collecting soil samples from six basins in native vegetation areas and adjacent orchards. Analyses revealed distinct microbial communities, where orchards exhibited higher bacterial richness but lower fungal diversity compared to natural areas. We suggest that copiotrophic-to-oligotrophic bacteria ratio was modulated by soil and landscape parameters. Furthermore, we found that the higher the copiotrophic-to-oligotrophic bacteria ratio the higher the soil heterotrophic respiration. However, interpretation can change if the efflux is divided by the total stock of organic carbon. According to our results, soil respiration was also associated to the soil N content and the proportion of particulate organic matter (POM) and mineral-associated organic matter (MAOM). Our findings underline the importance of considering both soil and landscape properties in managing the soil habitat, the microbial dynamics and optimizing soil respiration processes in agricultural settings.

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The cross-sections of soil services in substrates constructed for urban stormwater management: infiltration, fertility, carbon accumulation, and water-stable structural development

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Green competes with grey within urban spaces, placing demands of multifunctionality on the limited pervious surfaces designated to urban greening. Constructed soils, engineered from locally-available mineral and organic wastes, permit the element of purposeful functional design. Similar to artificial soil constructions, these soils not only allow us more control over a system, but also easier partitioning of the fundamental interactions within them. This joint-interdisciplinary project, as a part of DFG-funded Research Unit "Urban Green Infrastructure" (RTG 2679), aims to quantify and compare the mechanisms behind the soil services of infiltration, fertility, carbon accumulation, and water-stable structural development in substrates intended for municipal stormwater-processing. In previous experiments, we constructed substrate mixtures from locally excavated, carbonate-rich subsoils and municipal green waste compost, adding different quality biochars to act as pollutant sorbents. The biochar produced from woody waste material processed at high pyrolysis temperatures (BC850) showed exceptional retention of five common urban pollutants and significantly increased water-holding capacity in excavated subsoils while maintaining stability against microbial mineralization.

In the current study, we amend two calcareous subsoils of varying textures with BC850 to examine the cross-section of the soil functions of infiltration, structure, carbon storage and fertility in a system faced with intensive flooding, stagnation and drying (FSD) cycles. We quantify biochar's capability to recover species vitality parameters across soil textures, in turn exploring the development of root traits in grassland versus wetland species for resilience to flooding and saturation. We place emphasis on the systems' carbon balances, quantifying carbon pools from the plant to the rhizosphere to the bulk soil, with further intention of tracking biochar incorporation into the system – calculating biochar occlusion within aggregates and the residual within the light fraction that is considered susceptible to leaching. We then compare the formation of water-stable soil aggregates, and the size distribution relation to infiltration rate, as a function of plant development, biochar amendment and the strong impact of intensive FSD cycles.

First results on leguminous species *Lotus corniculatus* show that FSD cycles decrease above-ground biomass by approximately 50%, with the addition of BC850 recovering 30% and 35% of this biomass in the sandy clay loam and sand, respectively. Furthermore, this recovery of biomass under FSD cycles is likely a driver of further, synergistic interactions. Although biochar had no general effect on infiltration, biochar-induced recovery in below-ground biomass likely led to the significant interactions showing increased infiltration in the flooded system compared to the calcareous substrate without biochar amendment. This effect was evident in both soil textures and was not observed under the control watering system. The culmination of our results will further inform interactions between carbonate-rich parent materials and organic matter of different qualities within anaerobic water cycles in systems sensitive to leaching.

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Enhancing Soil Fertility and Wheat Productivity in Acidic Soils Using Biochar-Based Sustained-Release Fertilizer

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Soil acidity is a significant constraint in agricultural settings, leading to phosphorus (P) deficiencies due to the formation of insoluble or low-solubility compounds. This results in nutrient fixation, necessitating substantial conventional fertilization, which poses environmental risks. Smart fertilizers offer a promising solution for increasing nutrient efficiency in degraded soils. This study aimed to develop and characterize a biochar-based sustained-release fertilizer (BCRF) impregnated with nitrogen (N) and P for degraded soils and evaluate its effect on wheat growth and soil fertility compared to conventional methods. The research spans two cultivation cycles, comparing three treatments: a control, conventional fertilization (CF) with N and P, and BCRF. Each treatment was replicated in four randomized blocks. Soil samples were collected at various wheat growth stages to evaluate chemical and biological properties. The biochar was produced from oat husk, pyrolyzed at 300°C, and impregnated with N and P. The impregnation involved mixing biochar with urea and diammonium phosphate (DAP), followed by heating. Statistical analyses, including ANOVA and post-hoc tests, were used to discern treatment effects. Initial soil analyses revealed typical acidic soil characteristics. Soil incubation experiments measured the reaction to BCRF, emphasizing pH, N availability, Al immobilization, and P availability. Biochar treatments enhanced nitrogen availability and aluminum immobilization. The BCRF treatment increased nitrate levels and reduced aluminum toxicity more effectively than CF. Greenhouse trials with a spring wheat cultivar showed that BCRF and CF treatments significantly improved wheat biomass, spike number, grain yield, and nitrogen uptake compared to the control. BCRF yielded more spikes and seeds and increased grain N content by 38% and P by 33% compared to the control. Enzyme activities indicated increased microbial activity with BCRF, suggesting improved soil health. The findings suggest that BCRF can replace conventional fertilizers, offering a sustainable alternative by improving nutrient availability and reducing soil acidity and aluminum toxicity, supporting the integration of biochar-based fertilizers in sustainable agricultural practices.
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Keywords: Biochar, Sustainable agriculture, Nitrogen, Phosphorus, Soil fertility, Acidic soils, Crop productivity, Wheat.

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Methanogenic and methanotrophic activities along with the related microbial compositions in conetructed wetlands in different ages

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Wetlands are important carbon (C) sink and play a crucial role in mitigating elevated global CO$_2$ concentrations. However, they also act as significant global methane (CH$_4$) sinks due to their anaerobic soil conditions. The net CH4 efflux from wetland ecosystems is regulated by the dynamics of CH$_4$ producing archaea, known as methanogens, and CH$_4$ oxidizing bacteria, referred to as methanotrophs. Constructed wetlands, as ecological engineering technologies, can serve as important C sinks as long as the CH$_4$ emissions from the system do not offset the C sequestration rate. Understanding the dynamics of CH$_4$ and the soil physiochemical properties driving CH$_4$ emissions is crucial for regulating CH$_4$ efflux when designing constructed wetlands. Therefore, this study conducted a comprehensive analysis of methanogenic and methanotrophic activities, along with the compositions of active methanogens and methanotrophs, using DNA stable isotope probing (DNA-SIP) in three constructed wetlands of different ages in Taiwan. The results revealed that the methanogenic potential ranged from 0 to 0.41 μmol CH$_4$ g^{-1} soil hr^{-1} in the 2-5 cm soil depth. However, in the 0-2 cm soil depth, the methanotrophic potential ranged from 0.05 to 0.11 μmol CH$_4$ g^{-1} soil hr^{-1}. This finding suggests that methanotrophic activities may reduce methane emissions to the atmosphere by up to 25%.

Additionally, DNA-SIP results identified Type Ia methanotrophs, such as *Methylomonas*, *Methylobacter*, and *Methylosarcina*, as the predominant active methanotrophs. These organisms have previously demonstrated high CH$_4$ oxidizing potential. On the other hand, active methanogens such as *Methanosarcina*, *Methanosarseta*, and *Methanolinea* were found to be prevalent. Moreover, soil ammonium and sulfate concentrations were found driving niche differentiation among different types of methanotrophs in constructed wetlands.

The findings suggest that CH$_4$ dynamics are active in constructed wetlands, while the CH$_4$ efflux may be limited by the balance between active methanotrophs and methanogens. Moreover, controlling the concentrations of ammonium and sulfate in the inflow of constructed wetlands may be crucial for regulating CH$_4$ emissions from the system.

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Effects of oxygen-deficient water on microbial community dynamics in the lake-bottom sediment of Lake Kitaura, Japan

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Lake Kitaura, located in the southeastern region of Ibaraki Prefecture, Japan, is a eutrophic freshwater lake with a significant nitrogen load from the surrounding farmland soil. Recently, oxygen-deficient water often occurs at the bottom of Lake Kitaura due to the increase in summer temperatures caused by climate change. In the current study, we carried out metagenomic analysis in lake-bottom sediments to assess the lake-bottom environmental dynamics of Lake Kitaura. The amount of NH_4^+-N, total carbon, and total nitrogen are significantly higher at the site where oxygen-deficient water occurs in summer (S7: depth 6.35-6.45 m) compared to shallower sites (S1: 1.6 m, S3: 4.4-4.45 m). Moreover, the amount of NH_4^+-N in the sediment surface layer (0-5 cm) of S7 increases significantly when oxygen-deficient water occurs. According to shotgun-metagenomic sequencing, the biogeochemical cycling of the anoxic site in summer examined, resulting that the RPKM (reads per kilobase per million mapped reads) values of the ammonia oxidation gene (*amoA*) were significantly lower than those of the other genes related to the nitrogen cycle, and no gene cluster related to anaerobic ammonia oxidation was detected. These results showed that ammonia oxidation is the limiting step of the nitrogen cycle at deep water depth. In addition, the RPKM value of the urea degradation gene was significantly increased at the time of occurrence of oxygen-deficient water compared to when there was no occurrence, suggesting that the production of NH_4^+-N from organic matter was activated in the summer when oxygen-deficient water occurred, leading to further accumulation of NH_4^+-N. Base on the prokaryotic 16S rRNA-amplicon sequencing, predictive metagenome analysis was carried out to compare the microbial communities of S1 and S7. The results indicated that the appearance rate of OTUs (operational taxonomic units) presumed to possess *amoA* was lower at S7 than at S1. Furthermore, a negative correlation was observed between the appearance rate of OTUs presumed to possess *amoA* and the amount of NH_4^+-N. Furthermore, multivariate analysis indicated that the prokaryotic communities at S7 were influenced by NH_4^+-N. This study demonstrated that NH_4^+-N accumulates due to limited ammonia oxidation potential and that prokaryotic communities affected by NH_4^+-N in sediment of deep-water depth. Furthermore, our findings indicate that the production of NH_4^+-N from organic matter is enhanced during the summer months, when oxygen-deficient water conditions prevail, resulting in the accumulation of NH_4^+-N in the surface layer of sediment.

Development of technologies for producing biofertilizers based on organic waste and bacteria that promote crop resistance to drought stress

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The main goal of the INNO-MIK project is to develop technologies for producing biofertilizers based on organic waste and bacteria that support the crop resistance to drought conditions as support for the development of waste circular management and strategies for adapting to and mitigating climate change in agriculture. In the project, we are developing technologies for obtaining three types of biofertilizers based on: liquid digestate, compost and biochar, to ensure wider use of organic waste and a wider range of applications of these innovative biofertilizers. In all cases, biofertilizers become carriers of bacteria (PGPR – Plant Growth Promoting Rhizobacteria) supporting plant development in drought conditions. Every year, drought affects a significant part of agricultural land in Poland due to small precipitation and limited water retention in soil. The use of biofertilizers produced from organic substrates enriched with bacterial strains increases the resistance of crops to drought by improving water retention in the soil and stimulating plant immunity by microorganisms and substances contained in biofertilizers. Smaller yield losses mean a better farm economic effect, and therefore greater competitiveness of agriculture through adaptation to climate change. Given the wide range of mechanisms by which soil microbes can support plants (alleviating stress, providing nutrients through nitrogen fixation, phosphorus solubilization, production of phytohormones, siderophores, facilitating micronutrient uptake) and the extraordinary diversity of microorganisms, it appears that the potential of using of the technologies is substantial. Due to the need to reduce the use of synthetic means of production and the expected implementation of more sustainable agricultural production systems, the use of PGPR is becoming an alternative to conventional practices. An approach to minimize the harmful effects of over-fertilization of the soil while meeting the challenges of climate change while maintaining crop yields is much needed. The presentation will contain results of laboratory, glasshouse and field testing of the biofertilizer formulas with the emphasis given to effectiveness of bacterial processes supporting plant growth and effects of bacteria – organic substrate interactions for plant resistance to drought and plant yields.

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Modelling the spatiotemporal dynamics of organic carbon sequestration potential in cultivated soil by integrating digital soil mapping and process-based models

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Abstract

Farmland plays a crucial role in soil organic carbon (SOC) sequestration, and appropriate soil management can mitigate climate change and enhance global food security. To maintain soil health, it is necessary to understand and quantify the rate of SOC sequestration potential, considering both temporal and spatial variations. The SOC stock map of Taiwan was generated using a digital soil mapping (DSM) approach. Then, by integrating climate, soil texture, land use, and vegetation cover maps, the RothC model is employed to simulate annual organic carbon inputs and SOC stocks from 2021 to 2040. The aim is to evaluate the SOC sequestration potential across Taiwan under different soil management scenarios including business as usual scenario (BAU) and sustainable soil management (SSM) with the various carbon inputs (5%, 10%, 20% increase in carbon input compared to BAU), and the spatial resolution is 1 kilometer. The simulation results show that the SOC sequestration potential from 2021 to 2040 is -0.005, 0.039, 0.082, and 0.170 t C ha^{-1} yr^{-1} for BAU, SSM1 (5%), SSM2 (10%), and SSM3 (20%) scenarios, respectively. Under the BAU, SSM1, SSM2 and SSM3 soil management scenarios, the cultivated soils reaching the "4 per 1000" goal accounted for 2.48%, 11.9%, 23.7% and 78.0% of the total cultivated area, respectively. Additionally, it also found that the total SOC sequestration potential under the SSM3 scenario (0.289 Mt C yr^{-1}) can achieve the "4 per 1000" carbon storage goal of Taiwan (0.214 Mt C yr^{-1}). Our study provides spatiotemporal information on SOC sequestration potential in cultivated areas of Taiwan, serving as a reference for planning low-carbon farming implementation locations.

Keywords: RothC, soil organic carbon, carbon sequestration, spatiotemporal dynamics, digital soil mapping

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Multi-scale evaluation of the interaction between magnesium silicate hydrate and Aldrich humic acid

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Magnesium silicate hydrate (M-S-H) is a poorly crystalline mineral that is known as one of the anthropogenically synthesized binders of cementitious materials. In addition, M-S-H has been discovered to form at ultramafic bodies and it could be a precursor of clay minerals [1,2,3]. Clarifying how soil organic matters interact with such phases will demonstrate the possibility of carbon capture by poorly crystalline silicate phases in soils. Hence, this study aims to clarify the essential interaction of M-S-H with Aldrich humic acid (AHA), which was selected as a model soil organic matter. Two M-S-H chemical compositions, with Mg/Si ratios of 0.8 and 1.3, were investigated. The synthesis was carried out with the addition of 0, 5. 20 wt% of AHA that were hermetically cured for 3 months under 25℃.

The multi-scale structures of the synthesis products were investigated using Scanning Electron Microscopy (SEM), X-ray diffraction (XRD), ^{29}Si Magic Angle Spinning-Nuclear Magnetic Resonance (MAS-NMR), and neutron and X-ray small-angle scattering techniques. The Si polymerized state, basal spacing, and aggregation structure were found be influenced by AHA. For example, polymerization of Si of M-S-H with Mg/Si of 0.8 suggested an increase in the sheet size of M-S-H. M-S-H could modify their structures by coexistence with soil organic matters, which may be one of the processes of the soil organic matter fixation in soils. The interaction of AHA and M-S-H will be discussed further with the support of the listed solid phase analysis.

[1] De Ruiter L, Gunnæs AE, Dysthe DK, Austrheim H (2021),Solid Earth, 12:389–404.
[2] Lothenbach B, Nied D, L'Hôpital E, et al (2015), Cem Concr Res, 77:60–68.
[3] Nishiki Y, Sato T, Katoh T, et al (2020), Clay Sci, 24:1–13.

The amount, turnover rate and controlling factors of fractionated organic carbon in paddy soils in Nepal

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Accumulation of soil organic carbon (SOC) in paddy fields has considerable impacts on staple food production by maintaining and improving soil fertility. To obtain fundamental information on the status of SOM in paddy fields in Nepal under a variety of ecological settings, therefore, we investigated the amount and turnover rate of accumulated carbon in fractionated SOM using paddy soils in Nepal. Totally 21 soil samples were collected from the surface layer of paddy fields along an elevation gradient from 78 to 2002 m a.s.l. in the central part of the country. In addition, 8 soil samples were collected in the eastern region of lowland area to investigate regional difference of SOM status in lowland. SOM was fractionated into four components: 1) light fraction (LF) derived from plant residues, 2) heavy fraction (HF) forming aggregates, 3) oxidizable fraction (OxF) and 4) non-oxidizable fraction (NOxF) forming organo-mineral complexes with fine-textured minerals. The amounts of C in all the fractions were evaluated and Δ^{14}C values of selected samples were also evaluated as indices of the turnover rate.

The amounts of accumulated C generally increased with elevation from 78 to *ca* 1700 m a.s.l. but those of total C and C in the LF, OxF and NOxF showed decreasing trends from *ca* 1700 m to *ca* 2000 m, probably due to decreased biomass production and decreased soil amorphous minerals at *ca* 2000 m. The Δ^{14}C values indicated that turnover rates of C in the HF, OxF and NOxF were faster at higher elevation (1221 m) than those at lower elevations (78 m). Elevation gradient had, therefore, significant influence on the amounts and turnover rates of fractionated SOC in paddy soils in Nepal through the concomitant gradients of temperature and soil mineralogical characteristics. In lowland, the amounts and turnover rates of the accumulated C in the soil fractions were higher and slower in the central region and lower and faster in the eastern region, probably reflecting the difference in soil texture and mineralogy. Multiple regression analysis elucidated that C in all the fractions were negatively controlled by mean annual temperature, and C in OxF and NOxF were positively controlled by amorphous Al minerals ($\mathrm{Al_o}-\mathrm{Al_p}$). Coefficients for temperature further suggested that relative vulnerability of C to temperature increase was in the order of LF > HF > OxF > NOxF. These findings enable us to elucidate the mechanisms of SOC storage in paddy fields in Nepal which will lead to the establishment of sustainable agricultural management.

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Knowledge transfer between continuous and discrete SOM models in order to understand the stabilization of organic matter on mineral surface in contracting moisture.

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Abstract:

Two series of Black soils (Chermozems) each situated on the topographical gradient of moisture due to lateral water redistribution were studied. Moisture gradient 1 is situated in a dryer climate and moisture gradient 2 in wetter climate and the latter has moisture at lower topographical position exceeded the aeration level for extended period and Gleyic soils developed. In order to describe measured carbon pools in the upper 10 cm and upper 50 cm (all sites) as well as radiocarbon age at those depths (1 selected site) the Q model based on continuous organic matter quality concept was applied. The state variable of the Q model is quality, q, that can be described as decomposability of SOM that undergone microbial transformation for a given time lengths from fresh litter to stabilized SOM. Inevitable outcomes of this transformation are 1) the loss of matter in microbial respiration reactions 2) the dispersion of quality and general shift towards the molecular structure that is thermodynamically more stable (lower q). The model parameter □ describes the "speed" of shift in quality and parameter □ the strength of SOM physical protection on soil matrix. As a result of Q model site calibration, the model parameter □ is noticeably higher for soils on the site with dryer climate than for those with wetter climate. On the topographical moisture gradient 2 Gleyic soils receiving a lot of additional water input are contrastingly different from all soils by this indicator and have much lower □ . The higher value of the model parameter □ obtained during model calibration at wetter sites on moisture gradient 1 indicates that the substrate is more protected on mineral surfaces at these sites than at relatively drier sites of the same gradient. The model parameter □ obtained for the moisture gradient 2 higher than for the moisture gradient 1. Apparently, there are physical and physicochemical processes that better protect carbon on mineral surfaces at moistened Meadow soils compared to drier Chernozems.

In order to understand this phenomenon MEMS model based on POM, MOAM and DOM carbon pools was used. The soil moisture and temperature simulation validated by moisture monitoring at the

sites were used to drive the model. MOAM was measured at surface and deep soil at each site in order to validate the carbon pools of MEMS model. As a result of simulation, changing the input climate, including topographical differences in water supply, alone do not explain the differences in MOAM at drier and wetter sites that Q model calibration indicated clearly. Therefore, additional factors, such as difference in fungal and microbial residuals' composition and quality as well as of SOM interaction with Ca2+ cations as a function of water availability should be added to the MEMS model. We believe that large number of soil samples collected and analyzed at sites with contrasting local moisture legacy will allow to improve the MEMS, therefore making it possible to transfer the knowledge obtained by this detailed process-based model into lumped and thermodynamically conceptualized continuous quality model Q so that Q model can be used for the area without calibration.

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Nitrogen and phosphorus additions alleviate microbial phosphorus limitation in grassland ecosystems

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Abstract

Rhizosphere is the "hotspot" where plants, microbes and soil interact most strongly. Microbial phosphorus limitation is a condition of microbes have phosphorus deficiencies, which indirectly characterises phosphorus limitation in plants and soils. Increased nitrogen and phosphorus inputs in grassland ecosystems due to anthropogenic activities such as fertilization and fossil fuel burning are expected to intensify and alleviate microbial phosphorus limitation, respectively. Microbes in rhizosphere soil are more sensitive to nitrogen and phosphorus additions.

The coordinated distributed experiment network with unified control field experimental method is a powerful tool to test and integrate the mechanism of change in microbial phosphorus limitation. In this study, we use an nationally distributed global change experiment – Nutrient Network with eight grassland ecosystems in temperate and alpine region in China. Nitrogen (N) and phosphorus (P) were applied from 2018 annually ($10\ \mathrm{g\ m^{-2}\ year^{-1}}$) for three years prior to sampling, and nitrogen and phosphorus in combination were applied annually ($10\ \mathrm{N\ g\ m^{-2}\ year^{-1}} + 10\ \mathrm{P\ g\ m^{-2}\ year^{-1}}$). N and P fertilizer was applied as resin-coated urea and triple super phosphate [$Ca(H_2PO_4)_2$] in a single application in May or June each year. To explore the mechanism of microbial phosphorus limitation to three-year N and P additions, we use enzymatic and elemental stoichiometry methods in rhizosphere soil of Graminae family grasses. The ecoenzymatic stoichiometry method utilizes the ratios of b-1,4-glucosidase (βG) to alkaline phosphatase (AlP)

for calculations. The elemental stoichiometry method utilizes Soil$_{C:P}$ (soil dissolved organic carbon/available phosphorus), TER$_{C:P}$ (the ratios of microbial biomass carbon to phosphorus × the ratios of βG to AlP) for calculations.

Our results showed that (1) In Control treatment, ln(βG)/ln(AlP) ranged from 0.68 ± 0.03 (mean ± SD) to 0.94 ± 0.06 indicating microbial phosphorus limitation in eight grassland ecosystems. In P and NP addition treatments, Soil$_{C:P}$ – TER$_{C:P}$ response ratio ranged from -3.53 ± 0.33 to -0.67 ± 0.18 and from -4.04 ± 0.38 to -1.54 ± 0.23, respectively, indicating microbial phosphorus limitation was alleviated. In contrast to the prevailing view, N addition treatment decreased the value of Soil$_{C:P}$ – TER$_{C:P}$ indicating microbial phosphorus limitation was alleviated. (2) Nitrogen addition induced an increase in plant aboveground net primary productivity (ANPP), which in turn leads to an increase in organic acids, thereby alleviating microbial phosphorus limitation in eight grassland ecosystems. The Alleviation of microbial phosphorus limitation indicator in response to N addition increased with organic acid (F=11.04, $p<0.01$). ANPP and organic acids increased by 50% and 15%, respectively. (3) The relative abundance of phosphorus-solubilization to total phosphorus cycling genes accounted for about 13.5% and 12.4% in alpine grassland (Haibei) and temperate grassland soils (Hulunbuir), respectively. N addition increased the relative abundance of phosphorus-solubilization by 7.0% and 4.4%, respectively. Furthermore, N addition enhanced phosphorus-solubilization gene network interaction by 32.2% in temperate grassland soils (Hulunbuir). In conclusion, N addition alleviated phosphorus limitation mainly through phosphorus solubilization mechanism.

Overall, large-scale and functional gene results suggested that plant-microbial interactions alleviated microbial phosphorus limitation related to anthropogenic nitrogen and phosphorus eutrophication.

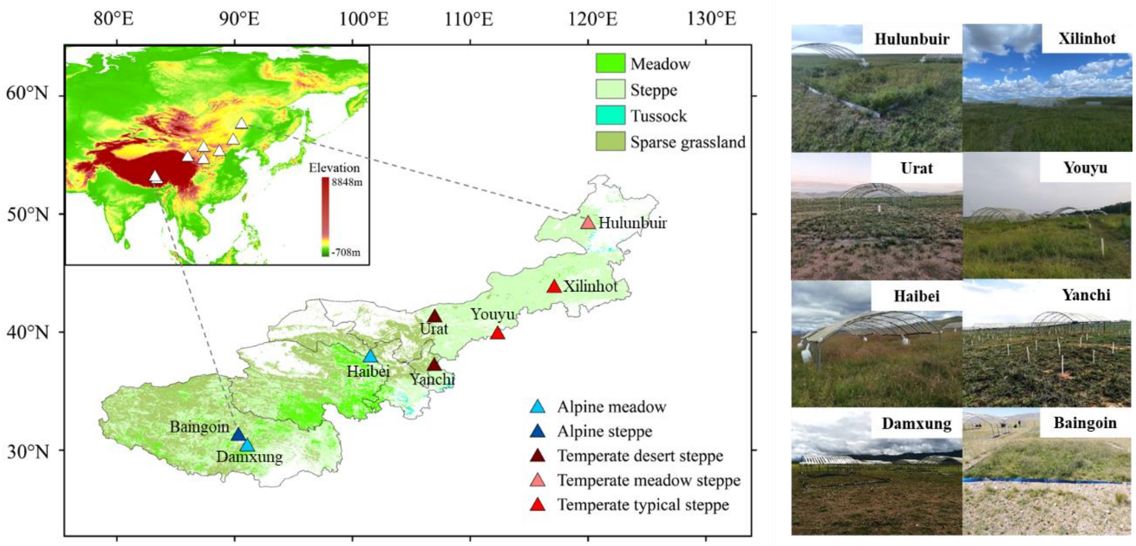

Figure 1 The location and grassland type of the eight study sites. Sites are ranging in latitude from alpine to temperate grassland ecosystems.

Session 5:

ISMOM as a basis for soil management and policy making

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Cropping intensification and diversification affect temporal soil aggregation and microbial activity in semiarid rainfed conditions

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In rainfed semiarid agroecosystems, adoption of certain management strategies may help to increase the resilience of these agricultural systems to global change and, particularly, to the provision of ecosystems services. Thus, soil health and nutrient cycling might be favored through the adoption of alternative management strategies which minimize soil disturbance and maximize cropping intensification and diversification. Consequently, in this study, we studied the adoption of different alternative cropping systems under no-tillage to the traditional cereal-fallow system (intensively tilled) in semiarid rainfed conditions. The alternative cropping systems tested were different crop rotations that combine different cereal and legume crops: barley (*Hordeum vulgare L.*), wheat (*Triticum aestivum L*) and pea (*Pisum sativum L.*). For this purpose, two field experiments were selected in NE Spain: Peñaflor (PN) and Sierra de Luna (SL). Specifically, the cropping systems tested at PN site were a continuous barley monoculture system, a pea-barley-pea rotation, a wheat-barley-wheat rotation, a W-B-W rotation and the traditional fallow-barley-fallow system. In SL, the cropping sequences were a barley monoculture system, a barley-wheat-barley rotation, a wheat-pea-wheat rotation and a pea-barley-pea rotation. Over two growing seasons (2019-2020 and 2020-2021), the following soil physical and biochemical properties were measured: dry mean weight diameter, water-stable macroaggregates, volumetric water content, permanganate oxidizable carbon, microbial biomass carbon, basal soil respiration, soil β-glucosidase and dehydrogenase enzymes activity. Over two years (2020-2021), seven topsoil (0-10 cm) samplings were performed at different times (winter 2020, spring 2020, summer 2020, autumn 2020, winter 2021, spring 2021, summer 2021). The results showed that whereas biochemical properties (microbial biomass and enzymatic activities) were more affected by temporal conditions, the physical properties (soil aggregation) were mainly affected by the cropping system. Cropping intensification and diversification resulted in greater soil microbial activity compared with the traditional cereal-fallow system. Soil physical and biochemical properties were positively correlated, explaining the role of soil aggregation supporting soil microbial activity. The suppression of long-term tilled fallow and the adoption of more intensified systems, in which different crop species are rotated under no-tillage conditions, are promising strategies to increase soil aggregation and soil microbial activities and, therefore, to enhance soil health status in rainfed semiarid agroecosystems.

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Soil spectroscopy: an alternative to wet chemistry for soil microbiological parameters

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Microbial biomass carbon (MBC) is a measure of the carbon contained within the living component of soil organic matter (i.e., bacteria and fungi). Soil microbial biomass is crucial for soil carbon dynamics, influencing breakdown processes and carbon pool formation, thus serving as a key indicator of soil health. Quantifying microbial biomass carbon (MBC) in soil and its relationship with various environmental factors is vital for effective soil management and climate change strategies. Traditional laboratory analyses for MBC, such as chloroform fumigation followed by incubation or direct extraction, are laborious, time-consuming, and thus unsuitable for large-scale assessments. Near-infrared (NIR) reflectance spectroscopy presents a promising alternative to wet analysis, offering rapid and environment-friendly soil microbiological analysis. In this study, we investigated the potential of NIR reflectance spectroscopy combined with machine learning techniques to accurately estimate MBC in the topsoil (0 – 10 cm) of an urban forest in Seoul, South Korea. NIR reflectance data (1400 – 2600 nm) were collected using ASD-FieldSpec after soil preparation, and partial least squares (PLS) regression was employed to develop predictive models for MBC. A total of 48 soil samples were collected along transects from the forest interior to the edge (0 – 40 m, 10 m intervals), with measurements revealing MBC ranging from 245 mgC kg^{-1} to 1,268 mgC kg^{-1}. The PLS model demonstrated satisfactory performance, with coefficients of determination (Adj. R_c^2) of 0.97 and root mean square errors ($RMSE_c$) of 29.7 mgC kg^{-1} for MBC in the calibration set. Leave-one-out cross-validation (LOOCV) further validated the robustness of the PLS model. These findings suggest that NIR reflectance spectroscopy-based estimation can provide reasonably accurate assessments of MBC across forest interior to the edge, offering the potential for scaling up soil microbiological analyses to city-wide assessments.

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Spatial Variability of Soil Greenhouse Gas Emissions in Oil Palm Plantation under Different Management Zones

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Oil palm (*Elaeis guineensis*) stands as an essential oil crop within the agricultural landscape of Malaysia. While considerable research has explored the spatial variability of soil properties in oil palm plantations, the existing focus on gas measurements has predominantly centred on carbon dioxide, often extending to the entirety of the plantation rather than delving into specific management zones. This study aimed to address this gap by quantifying carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) emissions in oil palm plantation within the three key management zones namely palm circle, frond pile, and harvester path. The study was conducted on nine-year-old oil palms cultivated in the Sulfic Endoaquepts soils with 30 sampling points per management zones. Our findings reveal compelling differentials across these management zones. The frond pile which recorded with the lowest bulk density and the highest organic carbon content, emerged as the most significant emitter, recording CO_2 emissions of 303.08 mg m^{-2} hr^{-1}, N_2O emissions of 0.4498 mg m^{-2} hr^{-1}, and CH_4 emissions of 0.2687 mg m^{-2} hr^{-1}. In contrast, the palm circle exhibited moderately lower emissions, with CO_2 emissions at 234.57 mg m^{-2} hr^{-1}, N_2O emissions at 0.0745 mg m^{-2} hr^{-1}, and CH_4 emissions at 0.0347 mg m^{-2} hr^{-1}. Meanwhile, the harvesting path displayed the lowest emissions among the management zones, with CO_2 emissions at 114.84 mg m^{-2} hr^{-1}, N_2O emissions at 0.1118 mg m^{-2} hr^{-1}, and CH4 emissions at 0.0313 mg m^{-2} hr^{-1}. These findings underscore the intricate interplay between soil management practices and greenhouse gas emissions in oil palm plantations which are crucial for future experimental sampling, ecological modelling, environmental predictions, and informed land-use planning.

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Dynamics of soil aggregate stability under different cropping systems in a long-term trial. Complex interplay between cropping practices, precipitation regime and soil organic matter.

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Abstract:

The assessment of different agricultural systems such as conventional agriculture, agroecology and their transitions requires an understanding of complex soil biogeochemical interactions. In this sense, different soil resilience mechanisms associated with aggregate structural stability synthesise the effects of disturbances from different practices, while directly reflecting the stability of biological niches (pore system) as a primary indicator of different land degradation processes. The complex evolution of aggregate stability, due to changes in tillage intensity, fertiliser and agrochemical use, intensity and diversity of crop sequence and climatic factors, among others, require a broad time frame of assessment. Thus, we evaluated from 1999 to 2023 the effects of different cropping systems in a long-term experiment at INRAE Versailles (France) in a Luvisol, (167 g kg-1 clay).

The treatments were: conventional (CON), low input (LI), organic (ORG) and conservation (CA). Tillage intensity: CON=ORG>LI>CA (CA=Direct seeding); use of synthetic herbicides and pesticides: CON>LI>CA>ORG (ORG null); use of fertilisers (nitrogen): CON>LI>CA>ORG; intensity of crop sequence (time of live roots): CA>ORG>CON>LI with a crop sequence for CON and LI dominated by oilseed rape, wheat and vetch, while for ORG various periods of lucerne and cover crops with interseeding of grasses and legumes were included for CA. Aggregate stability was determined using the method of Le Bissonnais (1996) (0-10 cm), which consists of three tests that allow observing different soil disaggregation processes (rapid wetting - aggregate slaking), slow wetting (micro-cracking) and agitation with previous ethanol wetting (cohesion). Crop sequence intensification index (CSI, period of sequence with living roots) and gramineae/legume ratio (G/L) were calculated for three periods (<1, <2, <3 years). All tillage treatments showed very low mean values (≈0.5 mm MWD), with the CA treatment (1.5 mm) being the most significant for the whole period.

These low values were mainly explained by the slaking test while the differences between the systems were mainly reflected by slow wetting. Since 2003, CA showed a sustained increase in aggregate stability, due to no-tillage and ISC<2 years (r: 0.69, $p<0.001$) and G/L<2 years (r: 0.60, $p<0.001$). Since 2011, oscillations with decreases were observed for CONV and ORG, suggesting that the effect of high tillage intensity (CONV) had a greater impact than crop diversity and ISC present in ORG. In general, rainfall in the last 30 days was negatively

associated with slaking but positively associated with other tests, indicating a complex interaction between aggregate stability mechanisms and rainfall.

Enhancing soil carbon sequestration in pomelo orchards through different cover crop adoption

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Abstract

Implementing cover crops (CC) in the orchards can foster an eco-friendly environment and enrich soil organic matter (SOM) content. Wentan pomelo is an important crop in Taiwan, and some regions still farm with conventional tillage (CT) practice, which was supposed would accelerate SOM depletion. In this study, we assessed the carbon sequestration capacity in the pomelo orchard and the impact of the CC on SOM. We conducted a comparison of the carbon sequestration capabilities among CT, spontaneous vegetation, and four different cover crops, such as white clover (Trifolium repens), fish mint (Houttuynia cordata), vaccinium fig (Ficus vaccinioides Hemsl. ex King) and wild peanut (Arachis duranensis), implemented for one year. Five soil samples were collected from the orchard to measure the SOM and soil bulk density (BD), providing data on soil organic carbon (SOC) change. After one year, SOC of the top soil (0-30 cm) of CT increased by 3 tons ha-1. Cover crops further increased SOC by a range of 4.8 to 12.4 tons ha-1, except for wild peanut. Furthermore, we evaluated the carbon stock by felling five pomelo trees, estimating a 110 kg carbon content for a 35-year-old tree. Combining the carbon fixation data obtained from soil and pomelo tree revealed that the orchard stored approximately 71.3 tons ha-1 of organic carbon for CT, and potentially increasing to 78.5 tons ha-1 with CC adoption.

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Influence of mineralogy, sesquioxides, and crop residue addition on soil organic carbon stability and associated microbial activity in diverse Indian soils

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Abstract

Recent focus on clay-mediated soil organic carbon (SOC) stabilization is crucial for understanding the global carbon (C) cycle. While previous studies centered on clay-organic interactions in geological deposits, pedogenic clay behaves differently due to its formation in diverse soil environments. Consequently, how natural clay minerals, along with oxides and external C inputs, impact SOC stability remains unclear. Thus, an incubation experiment was conducted in a sand clay mixture with various soil clay fractions (SCFs) derived from diverse Indian soils in presence of wheat residues to compare their C stabilization capacity. Higher C-mineralization rates were observed in 1:1 type dominated SCFs (Alfisol and Inceptisol) compared to 2:1 interstratified mineral dominated SCFs (Vertisol). Wheat residues influenced the SOC stabilization capacity of SCFs only at moderate dosages of application (3 to 12 g kg^{-1}). With increased amount of clay from 7.5% to 40%, C mineralization and microbial biomass carbon (MBC) fell by 40% and 30%, respectively. However, removing sesquioxides from the SCFs boosted C-mineralization and MBC by 22% and 16-32%, respectively coinciding with higher enzymatic activities in the sand-clay mixture. Vertisol-SCF exhibited higher C stabilization capability due to its larger specific surface area (506 m^2 g^{-1}) and cation exchange capacity (CEC) [meq/100 g]. Regression analysis demonstrated that SSA, CEC, and enzymatic activity accounted for approximately 86% of overall C mineralization changes. This study emphasized that 2:1 expanding clay minerals and sesquioxides were more effective in stabilizing external C input than their 1:1 counterpart. It also implied that the role of mineralogy or texture and sesquioxides levels in different Indian soils should be prioritized while adding crop residues to reduce C footprint and enhance C sequestration.

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Australian soil organic matter: NMR analysis of fine and coarse fractions

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The fractionation of soil organic matter into discrete components has been conducted for decades, with the aim of deriving greater understanding of its composition and function. In recent years, such processes have sought to move beyond operational fractionation towards methods that explicitly target the isolation of functionally discrete pools. One major focus of this generation of fractionation methods has been the isolation of a ‘fine fraction’ of ~ <50 µm, which is assumed to be dominated by organic matter associated with minerals, and is often termed mineral-associated organic matter (MAOM). Whilst MAOM is presumed to represent the more stabilised pool of organic matter, the coarse (~ >50 µm) particulate organic matter (POM) fraction is considered to be more labile, consisting mostly of partially decomposed plant material and other detritus.

However, within both fine and coarse size fractions, there is substantial chemical heterogeneity. This stems not only from the diversity of inputs to both fractions from plants and microorganisms, but also from the presence of resistant organic matter (ROM) that is presumed to be dominated by charcoal-like material. This material is functionally distinct from both POM and MAOM, but due to the heterogenous size of charcoal-like particles it is found in both coarse and fine fractions and would be included in POM and MAOM pools unless it is quantified separately in each size fraction. This is particularly problematic in Australian soils and those from other fire-dominated landscapes.

Here, we use the unique resource of ~800 pairs of ^{13}C cross-polarisation magic angle spinning (CP/MAS) solid-state NMR spectra from coarse and fine fractions of soils and sediments across Australia and beyond to understand chemical heterogeneity within the isolated size fractions. This dataset is particularly valuable as care has been taken to ensure consistent NMR conditions have been used on the same instrument across the >10 years of acquisition. Our results provide insight into the chemical stability of SOM across diverse ecosystems, adding extra value to the datasets obtained through size fractionation.

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Microbial controls on soil carbon stabilisation and greenhouse gas emissions in agricultural peatlands

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Peatlands are large terrestrial carbon stores and have an important role in global fluxes of major greenhouse gases including carbon dioxide (CO_2) and methane (CH_4). Lowland peatlands have been extensively drained for agriculture, forestry, and peat harvesting for centuries, and the oxidation and degradation of drained peat, and the consequent carbon loss, is of global importance. The long-term trends in CO_2 and CH_4 emissions and the microbial controls on peat degradation across agricultural lowland peatlands is poorly understood yet fundamental to policy and land management decisions. To evaluate soil carbon stabilisation in agricultural peatlands, we have established a sampling network across farms in the lowland peatlands of Eastern England, UK, known as 'the fens' where the peat has been drained from the 17th Century onwards; the once deep peats have degraded, with approximately two-thirds of the fens having peat < 40 cm depth and mixed with underlying clay minerals. We are testing how peat mixing leads to the formation of different soil organic matter pools (namely mineral-associated or particulate pools, which are expected to be stable vs. labile pools, respectively), and the relationships with microbial activity. We first assessed how *in-situ* CO_2 and CH_4 fluxes changed across a gradient in peat degradation (% organic matter to clay)—monitored over 12 months—to test whether losses declined when peat became increasingly mixed with clay minerals. We next assessed the formation of mineral-associated organic matter across the gradient, and how microbial biomass, composition and function changed accordingly. We then linked the physicochemical and microbial data with *ex-situ* lab incubations to draw links with heterotrophic respiration. Finally, we discuss the effects on the regional greenhouse gas balance of the fens and explore the implications for other agricultural peatlands worldwide.

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The patterns of forest soil particulate and mineral associated organic matter with latitude and soil depth

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Forest ecosystem is the largest carbon sink in terrestrial ecosystems, and nearly half of the carbon in forest ecosystem is stored in forest soils. However, the patterns of soil carbon in two main fractions of soil organic matter (SOM), particulate organic matter (POM) and mineral-associated organic matter (MAOM), across various types of forest ecosystems remain unclear. In this study, soil samples were collected from depths of 0-100 cm at eight sites located between 18 to 48 degrees north latitude in eastern China. The soil samples were then separated into POM and MAOM based on particle size to analyze the distribution of carbon within each fraction. The results showed that the carbon stored in POM increased with latitude and decreased with soil depth. Soil organic carbon (SOC) in the surface soil (0-30 cm) was primarily dominated by particulate organic carbon (POC), while SOC in the deep soil (30-100 cm) was lightly dominated by mineral-associated organic carbon (MAOC). MAOM experienced a higher degree of microbial processing than POM, with a more pronounced difference in microbial processing between MAOM and POM at lower latitudes than at higher latitudes. These findings contribute to a comprehensive understanding of the characteristics of forest SOM and offer potential strategies for enhancing carbon sequestration in forest ecosystems.

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Enhancing soil C sequestration and phosphorus retention in subtropical slope-lands using iron-modified biochar

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Soil organic carbon and phosphorus (P) are susceptible to water erosion, particularly in tropical/subtropical slope lands. Biochar has been considered an effective amendment to enhance soil C storage and nutrient retaining in soils. Biochar has the potential to decrease the nutrients leaching into watercourses, thus minimizing the risk of water pollution, but is very poor at retaining phosphorus. Loss of phosphates occurred through leaching especially at slope-land soils even with biochar application. In this study, three different biochar treatments were prepared including un-treated biochar (CK), acid-treated biochar (ATB), and iron-modified biochar (FeMB) to investigate the ability of FeMB to mitigate the erosion/leaching losses of phosphate in the soils and their interacted mechanism as well. The results indicated that Fe could be effectively co-precipitated on the biochar through observation of SEM elemental mapping. At initial concentration of 500 mg/L, the maximum phosphate adsorption capacity at 25℃ and pH 7 of FeMB was 327.8 mg/g, which was about 6 times the adsorption amounts compared to CK and ATB with adsorption capacities of 55.5 mg/g and 56.8 mg/g, respectively. The maximum adsorption capacity of FeMB by fitting the Langmuir isotherm model was 326 mg/g, indicating that the simulated value is close to the actual value. Iron-modified biochar (FeMB) showed an obvious reduction of zero point of charge (ZPC), alongside with results from Fourier transform infrared spectrometer (FTIR) analysis indicated that the main adsorption mechanism of phosphate on the FeMB is possibly by ligand exchange interaction. The XANES spectrum further indicated that about 60% P was transformed into Fe-binding form from Ca- and organo-binding forms in Fe-modified biochar. XAS spectrums also revealed that electrostatic attraction and ligand exchange (inner-sphere adsorption) are main binding mechanisms for phosphate in FeMB.

Exploring the potential of seaweed industry residues as organic soil amendments for carbon sequestration: insights from a plant-free pot experiment

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Organic soil amendments, such as exogenous organic matter (EOM), play a crucial role in enhancing soil organic matter (SOM) and mitigating climate change effects through carbon sequestration. EOM encompasses various organic materials derived from agricultural and industrial sources, including crop residues, compost, and organic by-products. These materials, when added to the soil, contribute to the enrichment of soil organic carbon (SOC) concentrations and foster soil health and fertility. The residues from the seaweed industry can be a valuable resource for use as organic amendments in agriculture. By focusing on the incorporation of seaweed industry residues into soil, we aim to elucidate their impact on SOC dynamics.

In this study, we investigate the effects of two seaweed industry residues (*Fucus vesiculosus* and *Ascophyllum nodosum*) on SOC stock and SOM composition in soils with varying characteristics. To achieve this, a plant-free pot experiment was conducted, testing two different seaweed application rates (2% and 4%). Soil samples were collected at five intervals over the year (0.5, 1.5, 4, 6, and 12 months after experiment initiation), followed by size fractionation, separating particulate organic matter (POM) and mineral-associated organic matter (MAOM) fractions, and measurement of carbon and nitrogen contents. The duration of seaweed persistence in the soil will be estimated by analyzing the distribution of carbon derived from seaweed among different SOM fractions, thereby providing insights into the longevity of their effects on soil carbon sequestration. Furthermore, our study contributes to the broader discourse on land management and carbon policy making by assessing the potential of seaweed residues in enhancing SOC stock and promoting sustainable agricultural practices. Preliminary findings are expected to shed light on the effectiveness of seaweed industry residues as organic soil amendments for climate change mitigation strategies.

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Making mineral and organic urban wastes interact to construct soils in cities.

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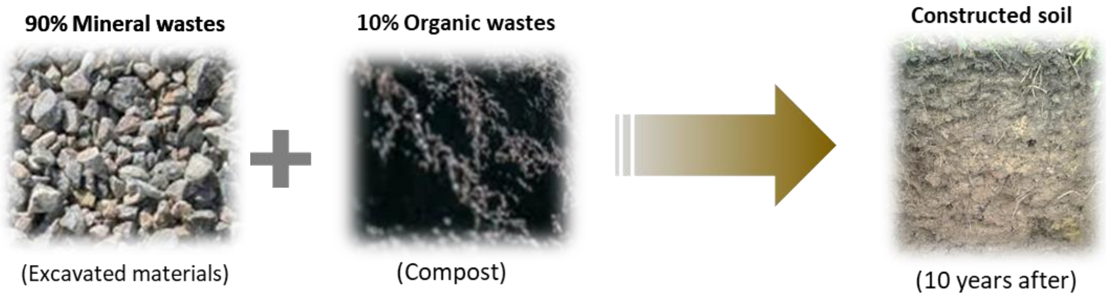
Urban green infrastructure (e.g. green spaces, bioswales, green roofs, green facades) provide numerous ecosystem services that could help offset the critical environmental problems of urban areas. Functional soils are a fundamental component of green infrastructure because they play a key role in supporting plant growth, infiltration, and biological activities. However, urban soils are often degraded and therefore replaced by natural resources (e.g. stripped natural topsoil, peat, natural aggregates). Constructed Technosols, consisting of a judicious formulation of organic and mineral wastes, are artificial soils tailored to specific requirements. This innovative solution, based on the circular economy, is expected to reduce the consumption of natural resources, increase the recycling of waste and ultimately contribute to the sustainable design of urban green infrastructure.



We present here the results of a decade of pedological engineering research on excavated mineral wastes from the Paris Basin (France). Every year, 15 million tonnes of this mineral waste are generated on construction and demolition sites and end up stored as hills outside the city, generating exorbitant ecological and economic costs. These materials are mainly composed of carbonated rock from alluvial sediments deposited during the Eocene. Although these materials are intrinsically not very fertile, the presence of certain clays such as sepiolite and palygorskite, as revealed by XRD analysis, give them certain interesting properties from a hydrous point of view. Initial laboratory experiments have shown that mixing green waste with certain quantities of compost not only promotes plant growth, but also diversifies microbial activity. The role of earthworms in the assembly of the organo-mineral complex and the physical structure of these Technosols was also demonstrated. These experiments were supplemented by long-term *in situ* trials which showed that after 10 years, the mixtures of mineral and organic wastes could be considered real supports for plant diversity, macrofauna and micro-organisms, with physical and chemical properties similar to natural soils.

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Fluorescent Properties of Soil Organic Matter Help Assess Sustainability of Agricultural Soils

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Abstract

Modern agriculture is generally exploitative, and improper farm management can lead to the degradation of arable land soil. To prevent soil degradation, regular application of organic fertilizers is necessary. The sustainability of agricultural land soil (appropriateness of farm management) can be evaluated by examining changes in soil organic carbon (SOC) content through long-term monitoring. However, a more accurate assessment of the soil environment can be achieved by adding soil organic matter (SOM) composition in addition to SOC content in the soil diagnosis. Thus, in this study, SOM composition was evaluated through a simplified diagnosis using alkaline extraction and fluorescence analysis with high sample throughput, from long-term continuously used soils with known application history.

A 200 mg of air-dried soil sample was transferred to a 10 ml centrifuge tube, to which 6 ml of 0.1M NaOH was added. After purging with N_2 gas, shaking extraction was performed for 24 hours. Subsequently, the solution was recovered by centrifugation and filtration. The pH of the solution was adjusted to 7.0 with HCl solution, and the excitation-emission matrix fluorescence spectra (EEM) were measured using a fluorescence spectrophotometer (Aqualog, Horiba). The EEM was decomposed into fluorescent components with different behaviors using statistical analysis based on the PARAFAC model on Matlab.

EEM analysis separated multiple peaks resembling fulvic acid, humic acid, and microbial-derived humus-like peaks through PARAFAC analysis. Soils from composted plots had a higher proportion of humic acid-like peaks, while soils from plots without organic fertilizer application had higher proportions of fulvic acid-like peaks. Soil organic matter is generally believed to undergo partial oxidation during decomposition, ultimately leading to mineralization. The results

obtained supported the hypothesis that in soils with organic matter application, unoxidized organic matter is regularly supplied, leading to generally lower oxidation states of soil organic matter. EEM measurements can be conducted conveniently and in a short time. This method is considered to be a useful and effective indicator for evaluating the sustainability of agricultural land soil.

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Sulfamethoxazole sorption mechanisms on organo-mineral associations and free organic matter fractions

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Sulfamethoxazole (SMX) is widely used in the swine industry and is commonly detected in manure and the broader environment. Swine manure is typically land-applied as a fertilizer in the liquid form (> 90% liquid). Dissolved organic carbon (DOC) in liquid swine manure is predominantly composed of fulvic acid (FA) and humic acid (HA). Free forms of FA and HA and organo-mineral associations with inorganic constituents, such as smectite clays, can control SMX sorption mechanisms in manured soils. Sorption is among the key factors influencing SMX mobility in the environment. This study aimed to investigate the influence of mineral-associated and free HA and FA fractions derived from fresh liquid swine manure on the sorption of SMX. The study used the DAX-8 resin-alkaline method to extract FA and HA from DOC in fresh liquid swine manure and characterized using solid-state Cross-Polarization Magic-Angle-Spinning ^{13}C-Nuclear Magnetic Resonance (CP/MAS-^{13}C-NMR), Fourier-Transform Infrared, and X-ray Photoelectron Spectroscopic methods. Subsequently, these FA and HA fractions were used in batch sorption studies to quantify SMX sorption onto a 2:1 clay. Alterations to the fluorescence intensity of free FA and HA due to SMX complexation was determined using 3D-Fluorescence Excitation-Emission Spectroscopy. The biochemical composition of FA and HA resulted in varied surface- and core-oriented functional groups, differentiating SMX binding mechanisms. Interactions between SMX and free FA involved fluorophore quencher mechanisms, engaging with surface-oriented phenolic groups. Conversely, interactions with HA involved non-fluorophore quencher mechanisms, interacting with surface-oriented carboxylic and amide groups. The organo-mineral associations of humic substances on the 2:1 clay alter physical conformation, significantly modifying SMX binding mechanisms. While SMX complexed with organo-mineral associations and free HA demonstrated stability, SMX complexed with free FA exhibited instability and desorbability. The abundance ratio of 10 FA:1 HA in the DOC fraction in liquid swine manure can promote greater SMX complexation with free FA, thereby enhancing SMX mobility and its transport to the environment via runoff or leaching. We propose the oxidation of phenolic groups in free FA through lagoon storage or composting of manure to reduce environmental dispersion of SMX.

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Chemical fertilizers and pesticides influence bacterial communities in chayote (*Sechium edule*) rhizosphere: A comparison of organic and conventional farming.

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Abstract

Bacteria play an essential role in biological cycles within various environments. To investigate the significance of bacteria in the rhizosphere those are associated with different farming methods, the 16S rRNA gene sequencing was introduced to compare the bacterial diversity between organic farming (OF) and conventional farming (CF) soil samples from the chayote (*Sechium edule*) root cultivated in Hualien, Taiwan. The OF sample yielded 3,643 operational taxonomic units (OTUs), covering more than ten phyla, while the CF yielded 3,680 OTUs. Interestingly, 2,399 OTUs were shared between both treatments, with approximately 30% of OTUs unique to each, and α-diversity did not significantly differ between treatments. Specific bacterial phyla, Deferribacteres, Absconditabacteria, Microgenomates, and Omnitrophica, were exclusively detected in OF soils. In contrast, Tenericutes, Bathyarchaeota, and Parvarchaeota were found only in CF samples. These results indicated that chemical fertilizers and pesticides may change the soil microbial community. Furthermore, OF exhibited a higher abundance of Nitrospirae and Actinobacteria, implying these two groups may have beneficial roles in OF. In conclusion, our research highlights the impact of chemical fertilizers and pesticides on soil microbial communities, offering insights into bacterial diversity between organic and conventional farming and providing a database to optimize chayote yield through bacterial utilization.

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A Comprehensive Understanding of Enhanced Rock Weathering Impacts: From Soil Organic Carbon Dynamics to Microbial Activity

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Abstract

Enhanced Rock Weathering (ERW) is a climate change mitigation technology that captures carbon dioxide (CO_2) and converts it into inorganic carbon, subsequently stored in soil or oceans. Furthermore, ERW can alter microbial activity by modifying soil physicochemical properties, potentially influencing soil organic carbon (SOC) dynamics. While individual studies have explored the changes in soil physicochemical properties or microbial community due to ERW, comprehensive experimental research that integrates the factors influencing SOC change remains scarce. In this study, we aimed to investigate the impact of ERW on SOC dynamics, particularly through modifications in microbial variables. We hypothesized that 1) ERW increases soil pH and nutrients, boosting microbial variables and 2) increased microbial variables stimulate easily degradable-C decomposition, leading to initial reduction in SOC. We conducted a four-month alfalfa pot experiment with olivine and blast furnace slag (BFS) application to soil. We measured soil pH and available nutrients, bacterial/fungal abundance ratio, microbial biomass carbon (MBC), exoenzyme activities (EEA), and glomalin-related soil protein (GRSP). SOC was fractionated into light fraction carbon (LFC), particulate organic carbon in macro- and micro-aggregates (Macro_oPOC, Micro_oPOC), and mineral-associated organic carbon (MAOC). Results showed that both olivine and BFS addition increased soil pH and available cations compared to the control. Unlike the pH and cation results, microbial variables (B/F ratio, MBC, EEA, and GRSP) remained unchanged in olivine but improved significantly in BFS. SOC contents decreased both in olivine and BFS soils, and the trend was most evident in the LFC. The discrepancy between soil microbial data and SOC decomposition indicates that SOC decomposition may be promoted by olivine addition through mechanisms not solely dependent on microbial activity, possibly involving lesser protection by aggregation than that by BFS. Overall results indicate that the ERW effect on carbon sequestration should integrate the dynamic characteristics of soil chemical, microbiological, and structural processes of SOC.

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Biochar input in subsoil can improve overall soil water profile and aggregate stabilization by biochar-plant rootage interaction under transplant condition

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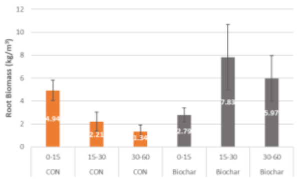
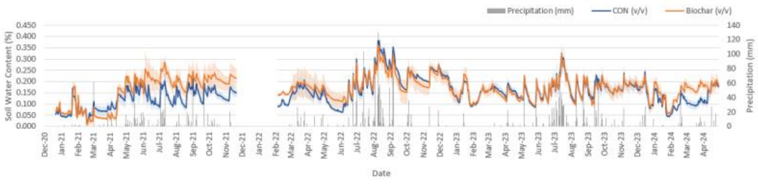
The addition of biochar (BC) into soil modifies soil structure and chemical properties, thereby stably sequestering C. Accordingly, it enhances aeration, water content, and nutrient retention, which collectively increases plant growth and microbial activities. These positive effects are more evident in active root zone when plants are tranplanted in urban greeneries. While BC's positive effects on rhizosphere are widely investigated, its long term field effects are less studied, especially in urban parks. To fill this knowledge gap, we introduced BC into two subsoil layers (15-30 cm and 45-60 cm depth) in a newly developed urban park setting and observed the changes in soil water content and root biomass during three years. In dry season, the soil water content in the surface soil (0-10 cm) of BC treatment was maintained higher than the control. However, in rainy season, there was no difference between the two. The total root biomass was higher in the BC treatment (5.64 ± 1.23 kg/m^3) than that of the control (2.46 ± 0.50 kg/m^3). In the control, root biomass was highest in the topsoil (0-15 cm depth) and decreased by depth. However, in the BC treatment, root biomass was the lowest in the topsoil, with higher root biomass in the two subsoil layers (15-30, 30-60 cm). This shift in root distribution suggested that BC input into subsoil may promote more root development in subsoil. The soil pore structure changes by biochar could be the main driver of extensive root development. To verify this, we plan to analyse the soil pore size distribution. Additionaly, we will evaluate whether the soil structural stability has improved due to the biochar-root interaction by analysing wet soil aggregate stability. The soil structural stability is expected to increase by biochar, which could facilitate C sequestration.





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Forms of sulfur deposited on soil by transboundary air pollution

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Although sulfur oxide emissions are decreasing worldwide, there is concern about the effects of past sulfur deposition on ecosystems. Sulfur compounds deposited on soils are in the form of organic or inorganic compounds. Organic S is divided into mineral-associated organic S and free organic S, which is oxidized to sulfate at a relatively higher rate during microbial decomposition. On the other hand, mineral-associated organic S is stable, not easily degraded and released at a slower rate, so it may continue to impact the environment in return for the function of reducing temporal sulfur release from soil.

The aim of this study is to determine whether soils in the Kajikawa catchment in Niigata, Japan, have large sulfur accumulations and whether the sulfur they retain is primarily mineral-associated organic S. This catchment is reported to be strongly affected by transboundary air pollution. We have previously found large sulfur accumulations in forest soils distributed in the Lake Ijira catchment, which is heavily affected by domestic air pollution (Tanikawa et al., 2022, Geoderma). The predominant sulfur fraction in the Ijira soils was mineral-associated organic S calculated from sodium pyrophosphate extractable sulfur (S_{pyp}) and phosphate extractable sulfur (S_{phos}). In this study, we constructed three soil profiles (up to 80 cm depth) and collected soil samples from each soil horizon in the Kajikawa catchment to compare soil sulfur storage and composition with the soils from the Lake Ijira catchment. Total sulfur concentration (total S) was determined by XRF method, mineral-associated organic S was determined by the method described above, and free organic S was determined by subtracting S_{pyp} from total S. We report the results of these analyses to discuss the soil function of sulfur accumulation in response to domestic air pollution or transboundary air pollution.

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Yield and soil status disparity under rice-wheat cropping system: A 40 years Journey

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Long-term soil fertility experiment is valuable for evaluating the effects of continuous cropping on the capacity of a soil to sustain nutrient supply and the productivity. Thus, experiment was conducted to know the impact of different dose and source of fertilizers on crop yields under rice-wheat system in Directorate of Agricultural Research (DoAR), Bara. The experiment was carried out in Randomized Complete Block Design (RCBD) with 12 treatment and three replication from 1991 to till date. In this study, we used the latest four years data viz. 2018, 2019, 2020 and 2021 for evaluating the yield and yield attributes of rice. The result showed that effective tillers/m^2, panicle length, thousand grain weight and yield were significantly ($p<0.05$) affected by the different nutrient management practices. Role of N was prominently noted. Use 100:30:30 NPKZn produced the stable grain yield of 3465 kg ha^{-1} as compared to other treatments. However, inherent soil nutrient capacity still supporting more than 1999±550 kg/ha yield without any fertilizer application. In meantime, lack of N, P, K and Zn of individual plot had variation in yield ranges from 2626 to 3253 kg/ha. The pH was highly reduced in other treatment to average 5.4 but remain slightly decline in control from initial. The organic matter , N,P, and K was constantly high in FYM treated plot but notice declined in other plot So, this concluded that use of organic matters could provide stable and higher yield and soil status over long period of time.

Key words: Fertilizer, Nutrient, Rice, Soil-Fertility, Yield

NBSOIL Academy for soil advisors – activating the potential associated with Nature Based Solutions

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Mission Soil project NBSOIL (Nature Based Solutions for Soil Management) is a four-year initiative which aims to co-create and test an innovative learning pathway for existing and aspiring soil advisors. The core product of NBSOIL is the Soil Academy which is a blended training programme prototype targeting both soil advisors connected to soils in agricultural, urban, forest and industrial regions. The training will provide participants with the tools to implement a holistic vision of soil health through nature-based solutions (NBS) and collaborate effectively across different temporal and spatial scales. Participants will engage with soil health and nature-based solutions experts, demonstration sites, advisory services, and other Soil Mission projects across the EU and associated countries to strengthen the knowledge and skills to provide nature-based advice on soils across all land use sectors.

The knowledge delivered to soil advisors is built around broad NBS categories: cover crops and intercropping, forest diversification, bioremediation, paludiculture, blue and green infrastructure and biowaste as fertilisers. Special emphasis is given to stimulating soil biodiversity and its beneficial role, and optimising interactions between soil organic matter, microbiome and soil minerals for soil health. The test areas representative for the NBS categories provide data and demonstration of the benefits coming from the tested practice – the examples are crop rotations stimulating soil biological life or application of biowaste fertilisers in agriculture, soil remediation and green are management in cities.

The NBSOIL Academy is structured into four modules, alongside a final project. The advanced Academy modules are: (1) Soil health and NBS, (2) Living Lab facilitation, (3) |Digital tools in soil advisory, (4) |Decision making in business and policy. The modules will be released gradually from June 2024 to May 2025. The Soil Academy platform, the modules, the co-creation process and the pathway from test areas to the Academy will be shown during the presentation.

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Organo-mineral interactions in a hard-setting Portuguese pasture soil

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Abstract

Hardsetting soil has been defined as a soil that sets to a hard, structureless mass during drying and is thereafter difficult or impossible to cultivate until the profile is rewetted. The production of a large quantity of primary particles as a result of the disruption and dispersal of aggregates during wetting is the greatest contribution to this phenomenon. Moreover, this behaviour is associated with loss of soil organic matter, specifically of the more labile fractions that convert to bonding agents. This study aimed to improve the understanding of the sustainable effect size and causal mechanisms behind biochar amendment on the sponge function of three hardsetting Portuguese pasture soils, sampled alongside a climatic gradient. We investigated i) key soil physical indicators by creating biochar dose response curves for three pasture soils along a climatic gradient; ii) penetration resistance in pots and the field; iii) particulate organic matter (POM) and mineral associated organic matter (MOM) fractionations; iv) soil aggregation. We found that at 10% (w/w) biochar mixture the gravimetric maximum water holding capacity (MWHC) increased by 92% on average for the three soils when compared to the control, with dry bulk density (BD) decreasing by 36%. Biochar amendment lowered BD for two drying out phases. Penetration resistance of compacted treatments over time decreased by biochar amendment, with a similar response pattern between the first and second drying out phases. SMC was positively affected by biochar amendment. From a 2-year field study, soil aggregation, root penetration, POM/MOM and reactive surface area results will be discussed.

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Changes in functional traits of cover crop oat and hairy vetch grown in Andosols with P fertilization on soil organic carbon and associated biophysical properties and nutrient cycling

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Green manuring cover crops (CC) are considered an environmentally friendly agricultural practice with multiple benefits. The benefits steered by the amount and functional traits (FT) of CC biomass due to different CC species and management practices are poorly understood. Effects of Oat and hairy vetch (HV) established with (+P) and without (-P) P fertilization on CCs' FT, which in turn affected soil properties, were examined on Andosols in NARO, Japan. Oat had a significantly higher C:N and C:P ratio than HV, and the amount of incorporated CC biomass (C, N, P, and K) was significantly increased by both Oat and P-fertilization. Regardless of the amount of C input either by Oat or HV, SOC increased by 1.1~1.2 t ha^{-1} year^{-1} at a 0–30 cm soil profile compared to the fallow. Both Oat (+/- P) had significantly higher water-retaining capacity of the soil at the pressure head (pF 1, 1.5, 2.7, and 4.2) and plant-available water (PAW) than those treated with HV. Oat (+P) further enhanced the saturated hydraulic conductivity (Ks) of the soil (Fig. 1). The soil microbiological properties were enhanced by P fertilization on both Oat and HV generally. Among the treatments, Oat (+P) showed the highest soil microbial population, colony-forming unit of total bacteria (TB), fungi (TF), P soluble bacteria (PB), phospho-di (Pdi), and monoesterase (Pmono) enzyme activities, microbial biomass C (MBC) and N (MBN), dissolved total N (DTN) and OC (DOC), then provided the highest soil inorganic N (IN), exchangeable potassium (K), and leafy Komatsuna fresh yield (Yld) (Fig. 2). However, the increase in SOC and TN due to CC was observed lowest by Oat (+P) (Figs. 1 and 2). The study highlighted the importance of P nutrient management during CC establishment on consequent CCs' FT and soil multiple benefits and revealed a possible trade-off between SOC and soil microbial properties, leading to better soil nutrient cycling with higher production functions.

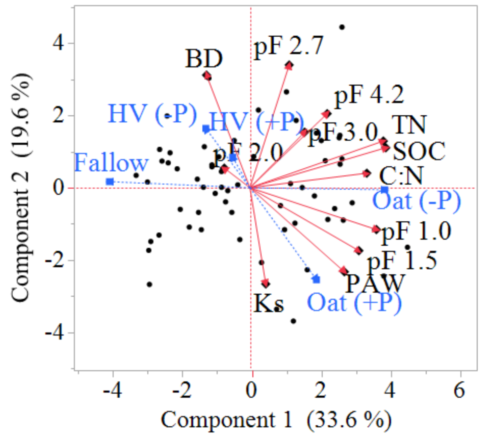

Fig. 1. PCA on correlations of soil physical parameters, SOC, and TN contents as affected by the CC treatments at the depths 0~5, 5~10, 10~15, 15~20 cm (*n* = 60).

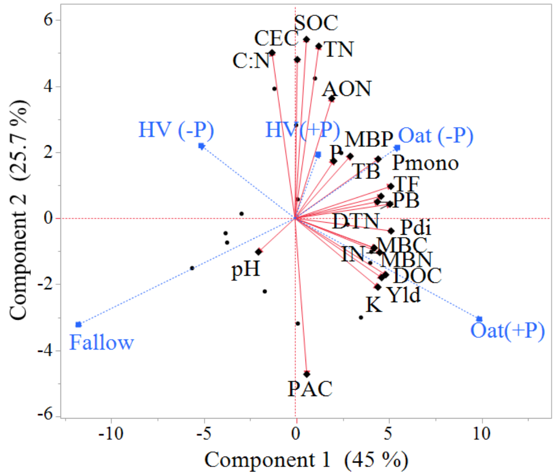

Fig. 2. PCA on correlations of soil microbiological properties, edaphic factors, nutrient contents and komatsuna yield as affected by CC treatments (*n* = 15).

Linking soil C stability and microbial diversity at different soil depths in Northern California vineyards

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Soil depth is one of the strongest predictors of carbon (C) stabilization in soils in different climates. Minerals and microbial drivers of C stabilization are often depth-dependent, such as the abundance and type of minerals, soil texture, moisture content, and microbial abundance and activity. These properties influence the capacity for C accrual and stabilization across soil depths. In cropland soils, microbial control may govern the C stabilization process in the intensively managed topsoil, while mineralogical properties may have a determining role in the relative undisturbed subsoil. Grapevine (*Vitis vinifera L.*) cultivation has been suggested to have a greater overall potential to store C than annual crops, due to the vine's deep reaching roots and C exudation. Vineyards from Old World to New World winegrape growing regions occupy an extensive range of soil types with distinct subsoil mineralogy and physiochemical properties, which may lead to great variability in the potential of C stabilization and accrual in the subsoil depths. Moreover, soil microbial communities greatly influence soil biogeochemical cycles, but their role in C sequestration, particularly in subsoil layers, is still not well understood. We surveyed the vertical distribution of indicators of C pools, microbial activity and diversity in three Northern California vineyards, each with a different establishment age but similar management practices and soil textures. We expect that C pool indicators vary by depth and will reveal patterns of these C pools. Further, we will investigate how soil microbial communities and soil C pools shift across subsoil layers by characterizing bacterial and fungal taxonomic composition and diversity across the four soil depths. Microbial community composition, diversity and activity are expected to correspond to changes in C stabilization at deeper soil depths. Our long-term goal is to use this as the foundation from which to examine impacts of soil management practices on linkages among microbial communities, soil C dynamics and stabilization, and soil properties with increasing depth in California vineyards.

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Blue Carbon Preservation Enhanced by Iron in Coastal Wetland Sediments: A Case Study in Yancheng, China

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Abstract here (200 to 500 words, Font: Times New Roman, Font size: 12. You may include figures or tables as long as they fit in this page)

Coastal wetlands serve as crucial transition zones between terrestrial and marine ecosystems, pivotal in carbon storage and sequestration. Salt marsh wetlands, a quintessential category within coastal wetlands, exemplify the key role of transitional ecosystems in carbon sequestration and storage. This study focuses on understanding the characteristics and dynamics of OC and Fe-OC in salt marsh sediments in Yancheng, China. In the current study, sediment samples were collected during winter and summer from three types of sediments: mud flat (MF), dominant by *Spartina alterniflora* (Sa), and dominant by *Phragmites australis* (Pa). Salinity differences among them are negligible, and the tidal levels between Sa and Pa are similar. Analysis revealed that Sa sediments showed the highest organic carbon (OC) pool (7.56 ± 1.08 $mg \cdot g^{-1}$) due to greater biomass and litter input. Furthermore, water-extractable OC (WEOC) from Sa sediments exhibited the highest OC concentration (554.17 ± 45.45 $mg \cdot kg^{-1}$), which indicated Sa sediments may release more OC into the surroundings than the others. Simultaneously, spectral analysis confirmed the dominance of plant-derived dissolved organic matter (DOM) in Sa and Pa sediments, contrasting with microbial-dominated DOM in MF. Furthermore, higher molecular weight, aromaticity, and DOM complexity compared with MF and Pa suggested the differences in organic matter sources and degradation pathways. Additionally, the inorganic Fe-OC extraction method (Dithionite sodium as DH, hydroxylamine hydrochloride as HH, and sodium pyrophosphate as PP) was introduced to assess Fe-OC contributions to OC burial in different sediments. Results revealed higher Fe-OC concentrations in Sa sediments for all three speciations of Fe-OC (Fe_{DH}-OC = 1127.08 ± 51.29 $mg \cdot kg^{-1}$; Fe_{HH}-OC = 390.11 ± 21.56 $mg \cdot kg^{-1}$; Fe_{pp}-OC = 1478.28 ± 163.09 $mg \cdot kg^{-1}$), while MF has either similar or lower results compared with Pa.

Overall, Sa sediments demonstrated superior OC storage capabilities, potentially releasing more active OC into the surrounding environment while concurrently

preserving a substantial portion. Fe-OC emerges as a crucial pathway for stable OC storage in coastal wetland sediments, with all sediment types showing capacity for future OC immobilization and Fe-OC complex formation. These findings underscore the importance of understanding Fe-mediated carbon preservation mechanisms in coastal wetlands for effective regional carbon management strategies.

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Comparative effects of Compost, Bokashi, and Trichoderma on soil and tomato quality in a Mediterranean area

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Biological soil amendments are claimed to promote soil functionality and enhance crop production. However, it is unclear how the effect of the amendments interplay with different soils and management practices. This study investigated the effects of Compost, Bokashi, and Trichoderma on soil and tomato fruit quality across different field conditions. The findings revealed that the amendments elicit varying responses in soil chemical fertility and microbial activity. Bokashi showed the most significant impact on soil chemical variables, with a higher soil organic matter content and higher total N and available P and K concentrations than the Control. Soil biological amendments also increased the abundance of plant growthpromoting rhizobacteria. These effects on soil quality did not guarantee yield improvements but changed tomato biochemical quality. All amendments increased anthraquinone content in tomatoes, which was attributed to higher soil microbial activity. Besides, plants amended with Trichoderma showed smaller fruits with higher phenolic content. On the other hand, tomato quality fluctuated among producers, highlighting the effect of local management and conditions while challenging the prediction of amendment effects. In this regard, the Actinomycetes abundance in the soil arises as a potential soil quality indicator that correlates with key tomato quality traits. Similarly, we provided a soil quality index based on adequate ranges of soil variables. These findings highlight the need for tailored amendment strategies based on specific site conditions to maximize the benefits of biological soil amendments in sustainable agriculture.

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